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THE ANTIQUITY OF DISEASE

ROY L. MOODIE

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THE ANTIQUITY OF DISEASE

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THE OLDEST KNOWN BONE TUMOR

This hemangioma, or vascular bone tumor, occurs between two caudal vertebrae of a large dinosaur, *Apatosaurus*, and has firmly united the two bones into a solid mass. All traces of an intervertebral junction are lost. The specimen was collected in the Como beds, Comanchean, of Wyoming, by Dr. S. W. Williston, at the time when these deposits were in the height of their fame as dinosaur quarries.

THE ANTIQUITY OF DISEASE

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TO THE MEMORY OF
SAMUEL WENDELL WILLISTON

PREFACE

The study of the ancient evidences of disease is known as paleopathology. The antiquity of the evidence is very great, measured in millions of years, and includes data from the oldest geological examples of pathology, from the earliest dependent associations of animals and plants, and from the appearances of disease on the remains of the ancient human races. The beginning and the exact time of closing the study of paleopathology are uncertain and somewhat indefinite dates. Perhaps we may say that the study of this subject includes material from the time of the introduction of animal and plant life on earth to the civilization of the continents by races which left written records of such things. The present little volume by no means undertakes to cover such an ambitious field. The evidence presented here is chiefly that of the fossil vertebrates and ancient human races, with slight excursions into other fields; the chief contributions being to Mesozoic pathology and early man. Restricting the discussion in this manner will enable me to give an account of my own studies on original material, and obviate any necessity of dealing too extensively with accounts of the researches of others.

The chapters of the volume are based on various brief papers previously published in the *Southern Medical Journal*, the *Bulletin of the Geological Society of America*, *Science*, and the *Scientific Monthly*. These articles were written in a non-technical vein, and contain material not otherwise recorded. They were prepared as side issues of a more comprehensive and detailed study of paleopathology, included in another volume, to be issued presently by the University of Illinois.

The prosecution of the study of fossil and ancient human material would have been impossible but for the assistance of friends in charge of paleontological and anthropological collections at Field Museum, Walker Museum, Peabody Museum at Harvard, the Yale Museum, United States National Museum, Princeton University, University of Kansas, and especially the American Museum of Natural History. All of the institutions loaned material or furnished photographs. By the aid of a grant from the American Medical Association, all of these institutions were visited and the evidence seen. The National Academy of Science, the American Association for the Advancement of Science, and the trustees of the Elizabeth Thompson Science Fund made other grants which have forwarded the work greatly.

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The manner in which various lines of investigation arise, the motives and acts which bring them into being, are of the greatest interest. Many avenues of thought develop as a direct outcome of previous studies, suggested by some unsolved phase of the problem. Some arise as a result of observations made in travel or exploration, while others develop from stray remarks or questions, chance seeds of thought dropped by the wayside. To the latter class my own studies belong.

While we were camped at an old Indian spring on the bare, dreary plains of Wyoming, huddling over a small tin stove in an attempt to ward off the chill of an unseasonable blizzard, Dr. Williston diverted our minds from bodily discomforts by telling us of the early paleontological discoveries in America; the hardships of Mudge in early days in Kansas; his own explorations in the same territory and in the dinosaur quarries of Wyoming; of the famous discoveries of Leidy, Marsh, and Cope. But of them all none excited my interest quite so highly as his discussion of Cope's discoveries of land and fresh-water vertebrates in the coal of Ohio. Here in the flapping tent amid a cold Wyoming blizzard began my interest in what later developed into a first serious paleontological study. Why the brief account of these lonesome, voiceless amphibians living in a noiseless world in the swamps of old Carboniferous times should have appealed so strongly to my imagination I cannot say; but from that day on thoughts of the Coal Measures Amphibia have been steady, comforting companions

Curiously enough a second series of studies, that on the ancient evidences of disease, discussed in this little book, began in a similar manner from a chance question of a friend as to paleontological evidences of disease in various museum collections. This was merely a small seed but it grew and developed a whole flower bed of thoughts. In reply to the question, mention was made of a set of dinosaur bones which as they lay in the museum seemed to have been broken during life and subsequently healed with considerable callus. Closer study of the specimen, kindly loaned by the University of Kansas, revealed the startling fact that the tail lesion of this ancient dinosaur was a bone tumor (Frontispiece), a *hemangioma*, the oldest bone tumor so far known. So the path of inquiry was begun. It lay first among the Mesozoic vertebrates, then among the mammals of the Tertiary and Pleistocene, back to the vertebrates of the Paleozoic, to evidences in fossil man, to the ancient inhabitants of the American continents, and finally, inspired by the writings of Marc Armand Ruffer, to the ancient Egyptians.

Unfortunately, the scope of the study was halted at the brink of the ancient invertebrates, which loomed as an unknown field before me. Lack of an adequate knowledge of these forms forced me to narrow the investigation to vertebrate evidences. Fortunately for the completeness of the subject, and for our knowledge of Paleozoic pathology, the study of "organic dependence and disease" in early forms has been made by a master in the paleontology of the invertebrates. The reader is therefore referred to the writings of John M. Clarke, listed at the close of chapter ii, for the details of paleontological evidences of the inception of disease on earth. Naturally a book bearing such a title as the present one does should include a discussion of the earliest evidences of disease and injury,[1] but I have chosen to restrict myself largely to vertebrate evidences.

Similarly, scant attention is paid to the evidences adduced by paleobotany. The evidences of disease among fossil plants have been presented by Dr. E. W. Berry as chapter iii of a large work on paleopathology to be published shortly.

My own studies really begin with the Permian, although earlier Paleozoic vertebrates have been studied but without finding pathological evidences. The Coal Measures forms, if diseased or injured, failed to show evidences of it in any of the many hundreds of specimens of these ancient vertebrates which have been closely scrutinized. Thus for a discussion of the paleopathology of the vertebrates we are forced by our present limitation of knowledge to begin with the Permian. This does not by any manner mean that disease and injury did not annoy earlier vertebrates, but that we do not know about it. Remains of Permian vertebrates bearing

[1] The data on early examples of disease and injury among the fossil invertebrates are collected by Edgar Dacqué in his book, *Vergleichende biologische Formenkunde der fossilen niederen Tiere* (Berlin, 1921), under the titles: (1) "Epökie, Parasitismus, Symbiose," pp. 457–76, and (2) "Regeneration, pathogene Schalen, Häutung," pp. 693–703. This work has come to me too late for a detailed discussion of the evidence.

pathological evidences have been called to my attention by Dr. Williston and by Dr. Case. The few instances known are certainly not all of Permian pathology. Studies so far made constitute merely an introduction to a study of the ancient evidences of disease among fossil vertebrates.

HISTORICAL SKETCH

Our knowledge of the antiquity of disease is contained in a body of facts which has been accumulated during the past one hundred and fifty years through the activities of various observers. The scattered and unrelated observations may be gathered into a coherent subject which has been called paleopathology, although the term was not proposed until near the end of this long period of observation.

Pathological conditions on the fossil bones of ancient animals were first recognized in Pleistocene mammals, especially those of the European cavern deposits. In 1774 the subject was opened by E. J. C. Esper, a professor in Erlangen, who described a lesion which he regarded as an *osteosarcoma* on the lower half of the femur of a cave bear. Later students revised his interpretation to a callus formation surrounding a badly infected fracture, and to this day osteosarcomata are unknown in a fossil condition. Goldfuss and Cuvier added to our knowledge of the subject in the opening decades of the past century by discussing lesions of fractures particularly in a Pleistocene hyena and a fossil ungulate.

The year 1825 is significant in the history of paleopathology because of the entrance of a medical man, Philipp Franz von Walther, by his description of the remains of cave bears preserved at Bonn, many of which showed pathological lesions. Von Walther's observations were so accurate and his diagnoses so reasonable that Virchow, studying the same collection seventy years later, could find little to change. Von Walther attributed the majority of the lesions to accidents, to the weather, but some had been visited upon the poor bears because of *the sins of their fathers.*

The next stage of advance was made by a paleontologist, one P. C. Schmerling, a Belgian, remarkable for his early recognition of the significance of the ancient human remains found in the caverns of the province of Liège. His studies in paleopathology resulted in a very fine memoir which was published as an appendix to his researches on Pleistocene mammals which appeared in 1835. I have been unable to find a complete copy of this work in America. He described lesions as the results of fractures, caries, necroses of other kinds, and a few neoplasms which do not belong to these categories; altogether as sensible a classification as we have had to this day. Schmerling thus early spoke of the importance of what he called a new science, that of the study of ancient diseases.

Twenty years later Mayer's memoir reviewed all previous literature, as well as adding to the subject by describing and figuring in a beautiful lithographic plate lesions on twenty-four bones of Pleistocene mammals. Mayer was a medical man and pays high tribute to the observations of von Walther. His sensible conclusions point out that nature's processes of healing were as potent in the Ice Age as now, as well as indicating the destructive effects of infecting bacteria.

There now entered the field a highly trained pathologist, a man known the world over for his studies in this subject, Rudolf Ludwig Karl Virchow, who may in many respects be regarded as the founder of our modern conceptions of pathological processes. Although his observations in 1870 on fossil bones were not important in themselves, yet they show an interest which produced much fruit twenty-five years later. In 1895 his study of the paleontological collections at Bonn reviewed the work of von Walther and added numerous other observations.

While work was developing among the Pleistocene mammals, a body of facts concerning the pathology of ancient man was being brought out, especially in a series of observations by anthropologists on the significance of trephining and other ancient surgical procedures of which there were evidences in widely scattered places. Trephining had developed in Neolithic times in France and independently at a much later period in Peru. Observations on fractures, dislocations, and joint diseases increased the interest in this subject. The fields of observation among ancient man and Pleistocene mammals were later merged into a coherent whole by Marc Armand Ruffer, whose studies on ancient Egyptians has had such an important influence on the development of paleopathology.

It will not be necessary here to record the scattered observations of paleontologists. This has been done elsewhere, but we have learned that from the close of the Paleozoic upward the vertebrates have not been free from disease, and there has been a progressive increase in bacterial infections, attacking even such sluggish beasts as the heavily armored dinosaurs, though it must be admitted that these infections were not of a disastrous nature so far as the dinosaurs were concerned. One of these giant reptiles carried an infected fracture containing several liters of pus for many months and may have expired as a result of the infection, though the wound appears to have healed somewhat.

NATURE OF ANCIENT DISEASES

Pathological conditions among the ancient vertebrates do not indicate types of disease differing from modern forms. There may be extinct diseases, but so far the difficulties of interpretation do not allow us to be sure. The details of structure compare so favorably with modern pathological types, that we may say that pathological processes have followed the same paths and ended with the same results then as now. So far as our studies have gone, no new type of disease has been recorded among ancient vertebrates.

DISEASE AS A FACTOR IN EXTINCTION

It is a noteworthy fact that many groups of animals became extinct before disease was at all prevalent. The eurypterids, a group of gigantic arachnoids, appear first in the lower Silurian rocks and had disappeared before the close of the Paleozoic. The trilobites, early crustaceans, were among the first of the higher forms to develop. They thrived continuously for many geological periods and ended their career with the Permian. Other instances might be cited but these will suffice to show that disease has not always been an important factor, since it was almost wholly absent during the periods of the early and middle Paleozoic.

Osborn has called our attention to the part disease may have played in the extinction of the mammals, basing his suggestions on the prevalence of certain diseases among modern mammals, such as the Texas fever, "rinderpest," biliary fever, and the diseases transmitted by biting insects, especially the tsetse fly. He did not, however, cite any instances in which disease is known to have played a part in the extinction of the ancient mammals, and it is not likely that epidemic diseases of which he spoke would leave any impression upon the fossilized skeleton.

The presence of several species of tsetse flies of the genus *Glossina* during the Oligocene is established by the studies of T. D. A. Cockerell on the insects from the Florissant shales of Colorado. This discovery is very suggestive of the possibility of a widespread epidemic of the *nagana* among the ungulates of the early Tertiary, a million or more years ago. It is of course impossible to determine whether or not these flies carried trypanosomes, but their definite occurrence in a horizon of the Tertiary rocks is certainly very suggestive of such a possibility, and must be considered as an extremely probable cause of extinction, and as an almost certain factor of disease in ancient times. If such a disease as the nagana did invade the Tertiary herds of horses and other mammals, there would be no osseous lesions left to tell the tale, since this disease is essentially an affliction of the blood and blood-forming organs, spleen, liver, and bone marrow, and does not attack the bones. Trypanosomiasis in modern cattle, mules, and horses of the Sudan, South and Central Africa, South America, and Southern Asia is due to the presence in the blood and blood-forming organs of *Trypanosoma brucei*, *T. nanum*, *T. dimorphum*, carried from the sick to the well by several species of tsetse flies.

The lesions on fossil bones, so far studied, are the results of accidents, or of infections, and none of them are extensive. It is improbable that any of these lesions were so severe that the life of the race was endangered, and only in a few instances may we say that the life of the individual was sacrificed to the disease. It is extremely doubtful if lesions of the nature of most of those seen in a fossil condition are ever fatal. They probably resulted in the loss of usefulness of the member afflicted and no other result was noticeable.

The present results of the study of fossil pathology indicate the early appearance in geological time and widespread distribution of diseases of many kinds, but none of them appear to have been sufficiently severe to have played a part in the extinction of any of the known races of vertebrates. They are to be regarded rather as chronic, infectious, or constitutional diseases which may have played a part in extinction, but there must have been some other and more powerful ally which is at piesent unknown.

CHAPTER I

PALEOPATHOLOGY

Paleontology and Medical History

Paleopathology has been characterized as the science which is destined to shed new light on old diseases. The subject is still in a formative state, and there is much to be done before a complete realization of its value is attained.

Its beginnings, our knowledge of which is largely of a speculative nature, are to be found in the associations of the earliest animals whose remains occur in Proterozoic rocks, their ancestors being buried in the great Archeozoic complex. Its culmination is in the nature of disease and injury in ancient and prehistoric man; the Paleolithic, the Neolithic, and other fossil men of Europe and Africa; in the ancient races of America; the Aztecs, the Nahua, the Chibcha, the Maya, the Inca, and the other numerous pre-Columbian races, of whose structure our knowledge is more complete; and in other scattered evidences of primitive peoples, whose remains come to us in archaeological and anthropological investigations. Its field thus covers all of the evidences of disease and injury prior to the opening of recorded medical history which begins with the writings of Hippocrates, Aristotle, Aetius, Alcmeon, Democritus, Empedocles, and other early writers on biological and medical subjects.

A closely analogous field, possibly a part of paleopathology, is the study of the evidences of disease in ancient monuments, stelae, pottery, sculptures, and engravings of many kinds which often picture faithfully deformed, atrophied, and injured parts from which we may read something of the pathology of the day they represent. Thus Hamburger has figured a stela from Egypt showing a figure of a man who, judging from the *talipes equinus* indicated on the stela, suffered in youth from infantile paralysis.

The study of paleopathology originated with the interpretation of pathological evidences among the Pleistocene cave mammals of Europe, whose skeletons were studied by Esper, von Walther, Schmerling, Soemmering, Cuvier, Mayer, and Virchow. It was extended by Ruffer, Elliot Smith, Wood Jones, and others to the study of the pathology of ancient Egypt and the subject was named paleopathology by Ruffer. More recently the evidences of pathology among the more ancient animals, particularly the vertebrates of the Mesozoic, have been studied.

Disease and injury among the early inhabitants of the earth during the Paleozoic are not so well known, but this is a field which can be cultivated and in which important results may be obtained. Recently, paleontologists, working with invertebrate fossils, have called attention to callosities on the shells of brachiopods and other shelled animals, indicating some form of traumatism; injuries to ancient molluscs which are possibly of a parasitic nature. If someone acquainted with the fossil invertebrates should attack this problem, I am sure a great deal could be learned, but so far as the present literature is concerned definite lesions seldom have been described.

The earliest form which pathological processes took, aside from those of a traumatic nature, were parasitic. Parasitism, preceded by mild forms of communism and commensalism, is known to be very ancient and to this influence, doubtless, the first forms of disease were due. Parasitic evidences have been described as old as the Devonian, and traumatic evidences are known as old as the Ordovician. Doubtless, close search would reveal other interesting evidences among the older forms of life, even as far back as the evidences of life itself, unless, as suggested elsewhere, infectious diseases were warded off by the great natural immunity which only broke down after ages of evolution, accompanied by racial degenerescence.

The part played by bacteria—and it is now well known that bacteria are very ancient—is still largely speculative. The pre-Cambrian bacteria so far known are supposed to have had an activity allied to that described by Drew for *Bacterium calcis* and other marine calcium-precipitating bacteria. Doubt has even been expressed as to whether the small bodies seen in the algal shales are really bacteria.

The results of infection by bacteria are not definitely known prior to the Permian. Bacteria and fungi, possibly, however, chiefly those of decay, are widely distributed and well known from the Carboniferous rocks. Here lies a wide field of research, although a difficult one, dealing with the origin of that type of disease which is so troublesome to humanity today. It seems probable from present evidences that a wide distribution of the bacterial types of disease and the resulting pathology is a relatively recent phenomenon, with an antiquity of a few million years, which, when compared with the scores of millions, possibly hundreds of millions, of years which animal and plant life have existed, is a very brief time. Future studies and more data may, however, modify this conception considerably. But as we ascend the geological scale of life, evidences of bacterial infections are more and more commonly found.

Disease may be defined in its primitive condition as an antagonism between two units of life, whether neighboring cells in the same metazoan, or between an animal cell and a plant cell. The presence of certain one-celled fungi in protozoans, if it results in injury to either, is a form of disease in its simplest aspects. We may have to look to conditions in the unknown Archeozoic for future knowledge of these conditions. Pathology, of course, is the disturbing results of this antagonistic association. The search for the earliest evidences of disease may be a fruitless one, and we may have to be content with speculations for some time to come, but in view of the recent great advances made in paleontological investigations the future seems bright.

The nature, classification, and cause of tumors among man and animals is an important phase of pathological research. It is interesting to find among the earliest evidences of pathology definite tumors due to parasitic influences among the Paleozoic forms. Later, in the Mesozoic, true tumors, osteomata, and a form of tumor with the characteristics of the modern tumors so far as organization is concerned occur and differ only in slight details from a similar pathology of more recent times. Tumors were apparently not very numerous, so far as we can read the record from the fossil bones, being known so far chiefly in the Mesozoic dinosaurs and mosasaurs.

Whether the study of these ancient evidences of disease and injury will aid in a better interpretation of modern pathology is not yet determined. It will certainly give a wider viewpoint to the interpretation of disease, and a study of ancient evidences extends our knowledge into the remotest periods of time.

PALEONTOLOGY AND MEDICAL HISTORY

The study of the ancient evidences of disease is a phase of medical history which must depend upon paleontological data for its extension. That pathological lesions, especially those on the bones, retain all of their characteristics after many hundreds of thousands and millions of years has been clearly shown and distinct evidences of disease are known as far back in geological time as the early Paleozoic. Evidences of traumatism, fractures with the formation of callosities on the inner surface of the shells of brachiopods, have been seen as old as the middle of the Ordovician. Reasoning from the theoretical aspects of paleopathology, on the basis of possible parasitism of early hosts, disease may have originated in the Archeozoic, but there is no definite, recorded evidence.

The relation of paleontological data to medical history is based on the assumption that the manifestations of disease are the same whether seen on man or in mammals, and the infection of a Cambrian crustacean by Protozoa is as much a matter of medical history as the presence of osteophytes on the femur of *Pithecanthropus*, the fractured ulna of the Neanderthal man, or bilharziosis among ancient Egyptians.

Many lesions are commonly seen among fossil vertebrates especially, and paleontologists have not referred to them at all, or merely mentioned them incidentally, forgetting that such evidences are of extreme importance in tracing the origin and antiquity of phenomena which are of such vital importance to humanity today.

The importance of paleopathology is that it gives an opportunity of studying evidences of disease over a great period of time, and especially is this true in regard to the data offered by paleontology. That the study of these evidences may aid in the solutions of problems which are at present not solved is evident when we consider that many epidemics which sweep the world are doubtless the result of an accumulation of changes over a long period of time. It is well known in medical history how whole populations have been swept away by scourges, which, had the people understood them, could have been avoided, and in the future when we come to understand all of the events of past history we may be better prepared to avoid future conditions of a like nature.

A disadvantage under which the student of paleopathology works is that the results of epidemics are scarcely ever recorded, especially in paleontological material. The presence of tsetse flies in the Oligocene of Colorado suggests the possibility of trypanosomiasis among the herds of artiodactyls and perissodactyls of the early Tertiary but it can be considered merely suggestive. The search for such evidences is, however, just begun, and we may in the future learn more of the epidemics which must have swept through the herds of early animals.

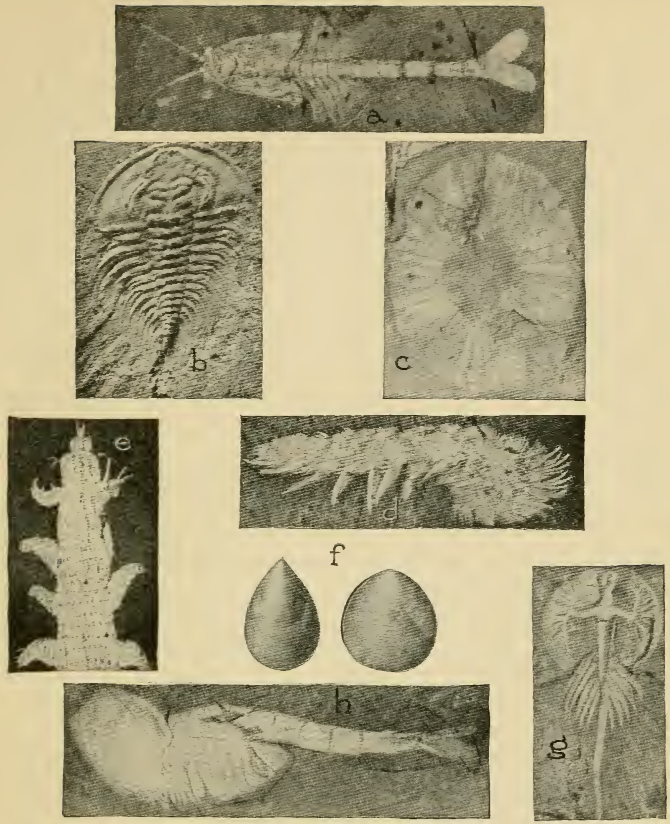

FIG. I.—Types of Cambrian animals which lived at the time when there was no disease. They were the highest type of animals then on earth, and while as we look back on these little animals they seem very primitive, yet they were descended from animal groups which had existed for millions of years. The soft parts of these little creatures might have been infected by sporozoans, and hence have been diseased, but we know nothing of this. The forms of animal life were crustaceans, molluscs, brachiopods, and related forms. The specimens were collected on the west slope of the ridge between Mount Field and Wapta Peak, I mile northeast of Burgess Pass, above Field, British Columbia, in rocks of middle Cambrian age. Since the brachiopods and other shelled animals form the greater proportion of the known Paleozoic faunas, it is among them that we must look for the earliest evidences of disease. *a*, a middle Cambrian crustacean; *b*, a lower Cambrian trilobite; *c*, a middle Cambrian jellyfish; *d*, a middle Cambrian spiny segmented worm; *e*, a middle Cambrian annulate; *f*, Cambrian brachiopods; *g*, a middle Cambrian crustacean; *h*, a middle Cambrian crustacean. (All figures after Walcott, in his *Evidences of Primitive Life.*)

The careful description, illustration, and study of ancient cases of fracture, diseased bones or any evidences of pathology is extremely desirable and will advance the study of paleopathology. Evidences of disease may be detected in the positions assumed by animals at death, the opisthotonos, the pleurothotonos, and related phenomena. It is a question open to discussion whether the opisthotonic attitude is a manifestation of disease, but it is as suggestive of neurotoxic disturbances as may well be. Whether the position assumed by the fossilized skeleton is the same as the animal assumed at death, how much is due to shifting before fossilization, are matters of minor importance to the student of medical history who is chiefly impressed with the fact that a dinosaur preserved in the opisthotonic attitude suggests to him the spasms seen in many recent diseases. The student of medical history is interested in a Mesozoic fracture because it extends his knowledge of traumatism, and if the study of the fracture is complete it adds to his knowledge of general pathology.

The relation of disease to extinction, and other more important relations, may be cleared to some extent by a study of paleontological material. The part disease has played in the evolution of forms, whether retarding, changing, or ending their development, also attracts the attention of the student of paleopathology.

Medical history, like all other histories, is based on an accumulation of data from widely different fields, and it is the privilege of paleontologists to add to the great wealth already accumulated more data as to what happened among the animals with which they are familiar, representing the inhabitants of the earth millions of years ago. The subject is worthy of more careful consideration than has been given it in the past. Paleopathology has attracted scant attention among paleontologists, but eminent students such as Cuvier, Soemmering, Goldfuss, Schmerling, Leidy, Williston, have found the subject of interest. It remained for the men who had been trained in pathology, men like von Walther, Mayer, and Virchow, to show the exact relation of pathological lesions among extinct animals to the general problems of disease which are interesting us today.

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CHAPTER II

ANCIENT BACTERIA AND THE BEGINNINGS OF DISEASE

Thread Molds and Bacteria in the Devonian
Bacteria in the American Permian
Mesozoic Bacteria
The Origin of Parasitism and the Nature of Disease during the Paleozoic

Germs are among the oldest inhabitants of the earth. It is even suggested that while the earth was still forming bacteria were carried from distant planets on meteorites and thus initiated life on the earth. However this may be, bacteria are found in the oldest fossil-bearing rocks of North America, having been discovered in central Montana in association with fossil algae, in the substance of which the bacteria were fossilized. Far from being disease producing the earliest types of bacteria were doubtless of the kind which assist in withdrawing calcium from the sea water. They were rock builders. An analogous form exists in the Atlantic Ocean at the present day, and is especially active around the West Indies in building up the coral reefs.

The form of these most ancient germs is so similar to that of recent bacteria that they are called *Micrococcus*, a bacterial form which is especially common today. Considerable comment has been aroused as to the possibility of such delicate organisms as bacteria being capable of preservation in a fossilized condition. This is, however, pretty definitely settled by investigations in other lines. Fossil brains, fossil flowers, fossil blood, and fossil muscle are known to be so well preserved that there is permitted an examination of the minute structure of the tissues. Renault, too, has described a great number of bacteria in the coal of France, so no doubt exists longer as to the structures seen being bacteria.

Disease, however, did not exist with the most ancient bacteria. Whether bacterial organisms were instrumental in effecting the origin of disease we do not know. This is a wide field of study which has not yet been explored. In a later geological period, bacteria are found in partially decayed bone, together with thread mold and other types of fungi. This condition, however, cannot be regarded as disease, but decay in dead material. The earliest animals were free from disease, although they were subject to injuries incident to the life of any creature. The larger attacked the smaller then as now. Infection of the injured part did not take place in the early periods of animal life, and it is only after the great Coal Period that infected wounds are found.

The Coal Period witnessed the earliest widespread condition of bacteria and fungi, and possibly witnessed the beginning of bacterial disease, although there had been previously a mild form of pathology due to the action of animal parasites. The first diseased conditions preserved are of course not the earliest manifestation of disease, since disease is doubtless the result of long ages of struggle between the two contending forces of nature. The early animals were so highly immune to attack by bacterial and other infective organisms that it was only after the races of animals began to grow weaker through age that disease was able to make any headway.

It is idle to attempt to place a beginning of any limited time during which disease began. Disease was not present in the earliest times of the earth's history, so far as animals and plants are concerned. The incidence of maladies began slowly, was introduced gradually, and has been an important factor only within relatively recent times. It was a minor and unimportant factor for millions of years.

The action of early parasites on the shells of ancient animals are our oldest evidences of disease. The activity of these organisms resulted in the formation of the oldest tumors. Diseased conditions of a very interesting type were caused in the early history of animal life by poisoning of the waters in which the animals lived. This resulted in a thickening of the shell, a twisting of the spirals of snails, or a diminution in size of some forms, certain of the depauperized individuals being only one-twentieth their normal size.

The origin and development of disease may be traced to a large extent from the evidences of pathology found on the fossil bones of the ancient races of man and extinct animals, as well as from the associations of the earliest animals. That early man may have acquired some of his diseases from the coexisting animals is evident from the fact that the men of the Stone Ages, the cave bears, and other cave-inhabiting animals were often afflicted with the same maladies, as may be seen from the diseased appearance of their bones.

It would thus seem that the relation between disease in ancient times and the extinction of great groups of animals like the dinosaurs was a matter of minor importance. The indications of disease so far seen on ancient bones are the results of accidents, or minor constitutional disturbances which did not endanger the life of the race, and seldom that of the individual. The evidence, to be sure, is scanty, being confined to that seen on the hard parts of ancient animals. But on a similar basis is erected our present extensive knowledge of the evolution of animals in past time. Many of the epidemic diseases of today, which are so fatal to life, leave no traces on the bones. It may have been so in past times, to a great extent.

The beginnings of disease are thus seen to be lost in an immense obscurity of time, during which the evil forces of nature were battling with the good for supremacy. Immunity doubtless was early established, and strongly intrenched. So firmly guarded were the primitive animals of the first ages of the earth that no disturbing influences entered into their existence. Only when racial old age and the introduction of other antagonistic influences disturbed this natural immunity, did animals see the new factor of disease enter into their lives. Early land animals doubtless lived long lives of placid contentment undisturbed by fear of infection either from within or without. Disease was in its very beginnings and with the land animals spread more and more over the face of the earth as time passed on in a mighty succession of geological ages.

THREAD MOLDS AND BACTERIA IN THE DEVONIAN

While making a comprehensive survey of the comparative histology of the skeletal parts of ancient vertebrates, in conjunction with the study of paleopathology, my attention was attracted to the enlarged and distorted shapes of many lacunae in the carapace of *Bothriolepis* and *Coccosteus*. Closer examination under the oil immersion revealed the occurrence of thread molds and bacteria in the almost disrupted lacunar spaces, and since these organisms have never before been noted in the osseous elements of such ancient vertebrates, a brief description will be given of them here. There is a great gap in our knowledge of ancient bacteria, especially between the pre-Cambrian bacteria described by Walcott and the Carboniferous forms described by Renault, so that we know nothing of the occurrence of bacteria in bony material during the early and middle Paleozoic.

The occurrence of thread molds (*Mycelites ossifragus*) in the hard parts of invertebrates and vertebrates, from mollusks to man, has been noted for more than eighty years, and the literature is very extensive. The canals made by the penetrating molds, known as the *Canals of Roux or Wedl*, have been noted by Kölliker in the hard parts of invertebrates, fossil and recent, by Triepel in recent human bones, by Shaffer in ancient human teeth, by Sonders in a Neolithic skull, by Roux in the skeletal parts of vertebrates, Carboniferous to recent. They have been recently seen in the bony parts of Devonian vertebrates. Doubtless they have a very wide distribution, and may be regarded as one of the most ancient types of organisms in existence. There is nothing peculiar in their occurrence in the ancient vertebrates except that their course of growth is modified by the histology of ancient bone. In the absence of definite lamellae, the mycelia often seek out a lacuna, enter it, and growing out along the direction of the brief canaliculi, expand both the lacuna and canaliculi until the entire structure is disrupted and the canals meet other canals growing out from adjoining lacunae. In modern human bone the mycelia very often follow the interlamellar spaces, but ancient bone has seldom any definite spaces of this kind and more often is to be regarded as an osteoid substance. That the appearances described for the enlarged lacunae are not normal is easily checked by a study of normal lacunae in the adjacent material. A single microscopic field will show both normal and invaded lacunae. The canals, from 2–4 microns in diameter, have an undulating course and offer easy channels of entrance to invading bacteria.

The presence of these thread molds would seem to indicate that the piece of bone showing them was preserved in a moist, sandy, or muddy place close to the shore, thus agreeing with our previous conceptions of the preservation of fossil material. It is difficult to see how the molds would find entrance if the material were imbedded under sand or silt in deep water. The ancient Egyptian mummies, buried for thousands of years in the dry sand of Nubian deserts, do not show such canals, nor do the Cretaceous vertebrates from Kansas show them. Seitz has figured them, though apparently did not recognize their nature, in the bones of labyrinthodonts and dinosaurs, and I have seen evidences of them in sections from the vertebra of an American sauropod dinosaur.

The bacteria doubtless have entered the bone along the course of the *Canals of Roux* and may be detected at first by the beady, nodular appearance of the canal. Often the bacteria, in *Bothriolepis*, for instance, have invaded a canaliculus which the Mycelites did not find.

The small clumps, or nodes, may clearly be regarded as colonies of bacteria and doubtless as a form of the *Micrococcus*, described by Renault in the canaliculi of Permian fish bone. The beady appearance of an invaded *Canal of Roux* or canaliculus recalls exactly the picture of the invaded dentinal tubules in cases of human dental caries. We are of course in this case, as in the case of other ancient phenomena, arguing from the known to the unknown. Here is an ancient situation which parallels a similar modern situation, and the argument is sound because on it for over one hundred years we have built the science of paleontology.

These conditions cannot be regarded as disease in any sense, but are rather to be regarded as the agents of decay and disruption at the present time, and from present evidences the same agents of decay have been at work for many millions of years, at least since Devonian times.

BACTERIA IN THE AMERICAN PERMIAN

The presence of bacteria in the closing period of the American Paleozoic has been suggested by the condition of a fractured reptilian spine, recalling an osteomyelitis. Careful search through microscopic sections of the spine has failed to reveal any sequestrum, such as is commonly found in modern chronic osteomyelitis, nor were bacteria found in the margins of the calcite-filled sinuses. The presence of pathogenetic bacteria in such a situation would be rather rare in a fossil state, since the nature of fossilization would prevent their preservation. It is doubtful, too, whether we could prove the pathogenicity of such bacteria save by their location.

Bacteria of the *Micrococcus* type, so common in the fossil vertebrate material studied by Renault from the Autun of France, are, however, abundantly preserved in the distorted osseous lacunae. They are similar in all respects to those occurring in the fossil bone of fishes previously described from the Devonian of America and Scotland. The bacteria, often seen isolated in the terminal bulb of the canaliculus-like burrows, which radiate out from the body of the lacuna, are no doubt those of decay and had nothing to do with the infection producing the osteomyelitis. There seems no doubt that bacteria of this type may be found in any fossil vertebrate material which has been imbedded in moist ground long enough to undergo a slight amount of decay, prior to fossilization. The only reason they have been seen so seldom in fossil vertebrate material is simply because no one has looked for them. They are there beyond any question.

The bodies which have been interpreted as bacteria, when seen isolated at a magnification of 1,240 diameters, measuring from 1 to 2.5 microns, appear as semicrystalline, rounded, brownish bodies, resembling minute specks of amber. The question as to whether they are really bacteria has been satisfactorily discussed by the researches of Bernard Renault, who has placed the subject of bacteriology of fossil vertebrate remains on a safe footing. Those seen in the present sections often group themselves in pairs recalling the modern *Diplococci.* I have never seen chains of these forms in vertebrate material.

The question as to how such minute bits of protoplasm are capable of preservation over many millions

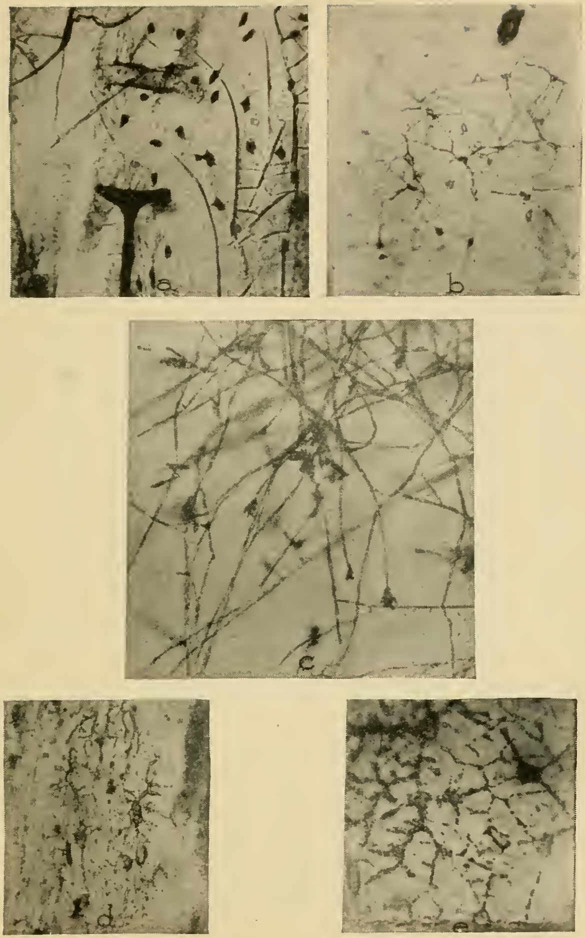

FIG. 2.—Examples of Carboniferous bacteria and fungi, as figured by Renault, who found his material in various types of coal, in fossil feces, and vertebrate remains. *a*, *b*, *d*, and *e* are sections of fossil fish bones from the Autum Basin of France, showing progressive destruction of osseous lacunae by the invasion of bacteria of the *Micrococcus* type. In *a* the black, diamond-shaped spots are normal lacunae with radiating canaliculi; *b* shows the nodular, beady appearance of the canaliculi, due to aggregations of bacteria in the minute canals; *d* shows the canaliculi greatly enlarged and distorted; in *e* the shape of the lacunae is so distorted as to be almost unrecognizable and the canaliculi are practically destroyed; *c* represents mycelia with spore cases of a fossil fungus, which had invaded ancient wood preserved as lignite in the fossil beds.

of years is one of those unsolved puzzles of paleontology which we may place with that of the fossilization of ganoid fish brains.

MESOZOIC BACTERIA

No definite studies on the occurrence of bacteria in the remains of Mesozoic vertebrates have been made. The bacteria are known to exist, however, though they are probably chiefly those of decay. Seitz in his study on the comparative histology of the bones of recent and fossil reptiles showed in a section of *Belodon*, magnified 360 diameters, many distorted lacunae and canaliculi. These objects have all the appearance of the lacunae distorted by bacteria and thread mold in the bones of *Coccosteus* and *Bothriolepis*. The magnified spaces seem to be packed full of bacteria. The distorted lacunae occur in clusters, as if the invasion had spread from a focus of infection, the more peripheral canaliculi inosculating with those from adjacent lacunae. Again in sections from the bones of a pterodactyl, *Rhamphocephalus Bucklandi*, from the Jurassic of Yorkshire, Seitz shows the results of invasions of the osseous spaces by thread mold and bacteria. Similar effects are shown in the bones of the giant dinosaur, *Iguanodon*, and I have seen similar lacunae showing very definite Micrococci in the toe bone of *Apatosaurus* from the Comanchean of Wyoming.

A second class of evidence is seen in the variety of necroses which are fairly common in the vertebrates of the Mesozoic. These are listed in detail at the end of chapter iv, so that no elaborate account of them is needed here. The nature of the necrosis may often be determined. In the United States National Museum there is a portion of a dermal armor of *Stegosaurus* which shows a necrosis on the dorsal surface due to an infected injury. There is likewise a specimen of another dinosaur, *Camptosaurus*, which shows an extensive necrosis on the upper surface of the right ilium. This was accompanied by considerable hypertrophy. Another giant land reptile shows in an infected fracture undoubted evidence of the presence of active, energetic bacteria. Not only are evidences clear among the land vertebrates but even in the water reptiles, the mosasaurs and plesiosaurs, there are undoubted effects of bacterial action, seen in arthritic lesions, in extensive necroses, carious roughenings, and alveolar absorption. It is of course impossible to assign any known type of bacteria as the cause of any of these lesions. It may be suspected that some of them were tuberculous in nature but it cannot be definitely determined. It is extremely interesting to find examples of rheumatism, alveolar osteitis, and dental caries in the Mesozoic vertebrates, indicating that *focal infections* are as old as many millions of years. Toothache and rheumatic fever doubtless disturbed the rest of the Cretaceous mosasaurs, as it did that of the pharaohs of Egypt and as it does many modern people.

THE ORIGIN OF PARASITISM AND THE NATURE OF DISEASE DURING THE PALEOZOIC

Parasitism began when there were forms developed capable of living at the expense of another. It has been suggested that parasitism, and consequently disease, began in the Archeozoic. This idea is based on the theoretical assumption of the infection of early hosts by sporozoans, a supposition which can be neither denied nor affirmed on definite evidence. It is true that most parasites leave little or no impress on the hard parts, hence the geological record is very incomplete in this respect, and we shall probably never know the actual beginnings of parasitism. The evidences of dependent life, symbiosis and parasitism, presenting themselves to the paleontologist, are chiefly of marine origin, since very little is known of early fresh-water forms. The

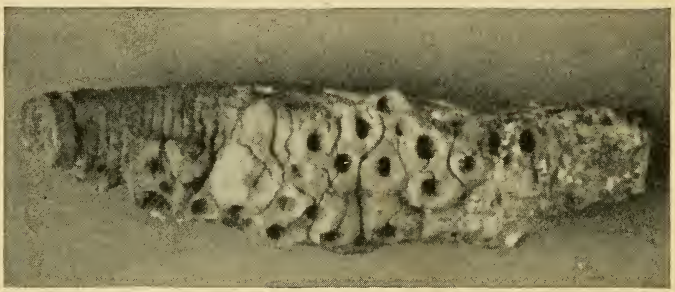

Fig. 3.—An idea of the simple nature of early pathology may be had from an examination of the present figure, that of a crinoid stem from the Bainbridge Limestone (Silurian), of St. Genevieve County, Missouri. The pathology is that of hypertrophy and is due either to incrusting organisms or worm tubes around the enlarged part, or the hypertrophy may have been in response to the grouping of the arms of the crinoid stem, the cirri, which may have all been attached on one side to be away from the strong water current. The pathology is benign and is on the borderland of a diseased condition. This is one of the oldest examples of pathology known. Crinoids were stalked animals whose stems were often the seat of infection by parasites, this being readily possible owing to the inactive nature of the stem; ×5. (The specimen was presented by Dr. Stuart Weller.)

ancient faunas show that these associations of dependent life began far back in the history of life.

There have been assembled materials from the older faunas of geological history which illustrate the beginnings of dependent life, thus attacking the problem in a practical way. John M. Clarke writes:

So far as our facts go there are but few evidences of true parasitic conditions in the Paleozoic faunas. The oldest and clearest is the well known case of the coalition of the limpetlike snail, *Platyceras*, and the crinoids. The snail settles down at an early age on the dome of the crinoid placing the aperture of the shell over the anal vent of its host and remains attached for an indefinite period of its subsequent life.

It is clear that the snail depends for its food on the waste from the crinoid and the fact that it remains attached for a very considerable period of its existence is shown by specimens of the crinoid dome bearing successive scars made by the enlarging growth of the mouth of the snail shell. Though this is the most extreme expression of ancient parasitism known to us, it was evidently of a very elastic kind and by no means affected all individuals of this genus of shells. This combination makes its first appearance in the early Devonic and seems to have become intensified in the great crinoid plantations of the early Carbonic but in either formation the examples of the actual dependent combination are in very slender proportion to the number of individuals of either snail or crinoid. Some of the snails acquired this habit of parasitic dependence, others evidently did not. Apparently it was in some measure an individual adjustment. Yet the more general dependence of this snail, *Platyceras*, on the crinoids is indicated by the fact that quite generally Paleozoic strata carrying an abundance of the one also abound in the other.

Time has not extinguished this affiliation, for the existing seas afford occasional evidences of similar relation between the limpets and the crinoids. Our material seems to throw some light on the inception of this dependent habit. A crinoid, *Glyptocrinus*, from the Upper Silurian is occasionally found inclosing in its arms a holostomatous snail, *Cyclonema*, not attached to the dome, for the shell had not the limpet habit of attachment but lying free in such attitude as to get the full advantage of the crinoid's waste.

True dependence is also indicated by a similar association between the crinoids of the Carbonic rocks and the starfish *Onychaster*. The starfish adjusts itself, mouth downward over the anal aperture of the crinoid. Our specimens showing this condition have been caught in this act of feeding. The flexible character of the starfish made the attachment easily subject to change. This association too is one that time has not cured.

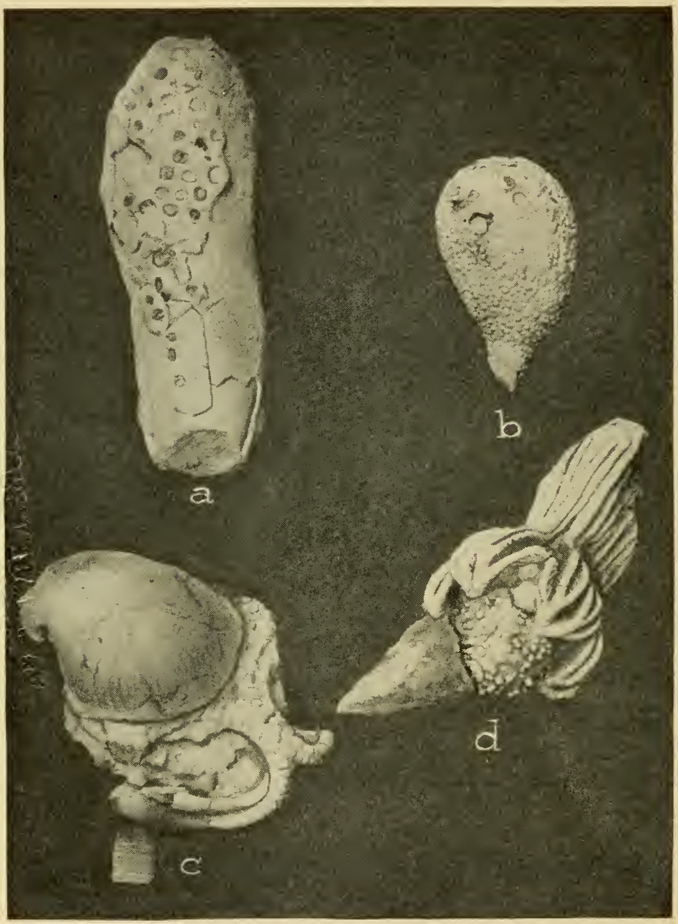

Fig. 4.—Examples of Paleozoic parasitism. These associations are on the borderland of diseased conditions representing the beginnings of a dependent existence which later resulted in a definite pathology. *a* and *b* are cystids from the Silurian, fossil echinoderms, which have been incrusted by some small animal such as sponges or bryozoans; *c* and *d* are examples of Paleozoic parasitism, indicating a dependent relation between snail shells and crinoids from the Upper Coal Measures. The snail shells, cap-shape in form, are seen to be applied closely to the dome of the crinoid, on the waste of which they fed. Dr. Clarke has described these associations in detail. (Specimens in Walker Museum, University of Chicago.)

Commensalism and symbiosis are the natural precursors of parasitism, and these associations became established more abundantly and at an earlier date than parasitism. Several writers have described a number of examples and have illustrated a variety of Paleozoic symbiotic associations.

The coexistence of the tubicolous worms with the corals became established at a very early stage in the earth's history, and in the Devonian coral reefs the habit had already become widespread and varied. The association was probably less frequent in Silurian times where the oldest known examples indicate an elementary example of commensalism.

A typical case of symbiosis, involving the association of a hydractinian and a hermit crab, has been described from the Eocene of Egypt, and has been called "Kerunia" after a place where it was found, Birket-el-Kerun. Fraas described similar recent forms from the Fiji Islands. While the fossil Kerunias consist of hydractinians which have grown around small snail shells, the recent ones have been formed upon a nucleus of serpulid shells. In the fossils the gastropod shells which had been overgrown by hydractinians had later served as dwelling-places for hermit crabs.

Robert Etheridge first recognized the nature of the swollen stems of fossil Carboniferous crinoids although he was unable to determine the parasite. He found on opening one of the enlargements that a fossilized worm was evident as a piece of black matrix reposing against the farther wall of the cavity. Graff was able to confirm the findings of Etheridge and recognized in the carbonized remains the fossilized integument of a myzostomid. Graff remarks:

All deformities on fossil crinoids due to myzostomids belong to two categories of arm enlargements as represented among recent species. All fossil myzostomid deformities occur on the stems of crinoids, where the lesions are of many kinds. Many of the described cases of deformity of the stem are due to accretions of corals, bryozoans and brachiopods, but there are numerous authentic cases of stem enlargement which have involved two or more arms.

There are a number of instances showing a symbiotic relation between the fossil hexactinellid sponges of the family Dictyospongidae and worm tubes attached to the inner wall of the cloaca of the sponge. Associations of the sponges and annelids are also known. The associations of corals and barnacles is known from the Silurian and Devonian. An association of crinoids and cystids with gastropods doubtless is an instance of genuinely dependent parasitism where an attached organism relies upon its host for its nutriment and existence. Keyes has recorded a long list of these parasitic associations and especially indicates the effect of this condition in modifying the aperture of the gastropod.

Examples of pseudoparasitism are indicated by the boring forms on dead shells, material which forms a large part of the fossils studied by paleontologists. These boring bodies infesting the dead shells are likely to be either minute algae or fungi, or sponges of genera producing similar effects to the living *Cliona* or *Vioa*. The total amount of deterioration and disintegration of skeletons caused by these minute organisms was doubtless great even in Paleozoic times. Boring pelycopods were not unknown in the early Paleozoic, and have been freely described in Mesozoic faunas as well as boring insects in the woods of the Tertiary.

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CHAPTER III

PALEONTOLOGICAL EVIDENCES OF THE ANTIQUITY OF DISEASE

Fossils are not only horizon markers, but as evidences of former life they bear the oldest indications of disease. Fossils form a wide range of objects, from a mammoth frozen in the ice of Siberia to an impression of a leaf in clay. While they are always preserved in sedimentary or stratified rock, yet they may be found in the greatest variety of places. They may have been eroded from their original bed and again buried in secondary sediment. They suffer from frost, from water transportation, from disintegration, from mineralogic deformation, and from a variety of other causes, so that only an expert paleontologist can determine when a fossil bears evidence of disease or when it is deformed by the growth of internal minerals. Often the stems of crinoids are converted into geodes, lined with beautiful calcite crystals. These geodes, in their early stages of formation, look like other enlargements in crinoid stems, known to be due to the presence of parasites. A shell may be fractured by the growth of a crystal so that it is difficult to determine whether the crack is due to a traumatism during life, or is a postfossilization affair. Through all of these vicissitudes the fossils find their way to the hands of the paleontologist who must exercise great care in discriminating phenomena of a pathologic nature.

That fossils do bear evidences of disease and injury has been observed for more than a century and a half by a great number of paleontologists. They bear these evidences because in life the animals are subject to mechanical injuries, such as the crushing or breaking of bones or shells by wave shock, by falling, or by being attacked by some larger animal. Parasitic lesions are caused by the presence of worms, sponges, corals, algae, or other organisms which become attached on, or bore into, the shells of living animals or the unprotected columns of living crinoids. This type of injury is commonly seen in the irregularly thickened walls of oyster shells which have been attacked by sponges. As soon as an animal dies its remains are subject to bacterial action, which often causes the complete dissolution of the parts, leaving no trace, or, as frequently happens, the partially decayed remains are fossilized and furnish evidence not only of the animal but of the bacteria. Such instances are described from the Devonian and Permian in the previous chapter. Bacterial sinuses, too, may be formed in the living, and are sometimes found as decayed teeth, arthritic lesions, alveolar fistulae, and other instances. Bacterial diseases of fossil plants and lesions produced by fungi are known. In a few cases there has been a general faunal pathology produced over an extensive area by the poisoning of the waters, resulting in depauperized individuals. A weakened or senile condition is indicated, too, in the presence of enormous spines or excrescences developed in a variety of forms. Such an example is the spiny reptile shown in Figure 5, a land animal from the Permian of Texas. All of the foregoing types of cases, preserved on fossil remains, are interpreted as the paleontological evidences of the antiquity of disease.

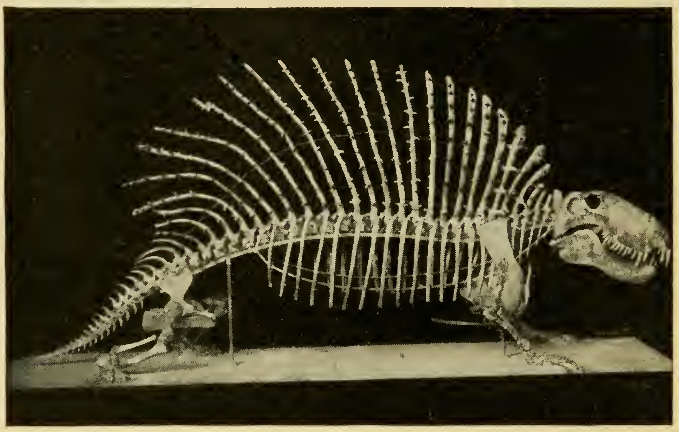

Fig. 5.—A long-spined reptile from the Permian of Texas. The huge development of the vertebral spines is thought to be an indication of racial degeneration or senility, and is hence a phase of disease. Many different races of animals show, toward the close of their period of existence, a tendency toward the development of external excrescences of the hard parts. One of the spines of this reptile had been broken near the tip during life and presents an interesting example of a Permian fracture. (Skeleton mounted in the American Museum of Natural History. Courtesy of H. F. Osborn.)

Pathological conditions among fossil animals are known as far back in geological time as the early Paleozoic, hence it may be proper to state on the basis of our present knowledge that disease began among both plants and animals at this time. These evidences are found both in the new and the old world, so that there must have been a very fundamental condition underlying the evolution and development of animal and plant races which favored the ingress of disease and the overpowering of the natural immunity which had previously protected the forms of life from the devastations of disease. This statement of affairs implies the absence of disease, or of a tendency toward disease, among the inhabitants of the earth during the early geological periods. This may not be correct, but so far as we know at present the animals of the Proterozoic were free from disease.

CARBONIFEROUS

Present evidences tend to show that the Paleozoic witnessed the origin of disease. One of the oldest known evidences of pathological conditions among fossil animals is found in the enlarged stems of fossil crinoids (Fig. 3), which have been known for many years. They were described by Robert Etheridge, from the Carboniferous of Scotland. Five years later a correct interpretation of these deformities was given by L. von Graff. He showed, on the basis of similar enlargements among recent crinoid stems, that these enlargements were due to the parasitic action of myzostomids. Graff supported his interpretation by describing the carbonized remains of some worm, supposedly one of the myzostomids, to which the tumor was due, preserved in a channel of one of the fossil lesions.

During the Carboniferous, also, there was a widespread development of fungi and bacteria which doubtless were influential in the spread of disease. Renault has found these forms abundantly preserved in the fossilized feces of fishes, in ancient wood, and in coal. He also discovered in the teeth of certain extinct fishes indications of caries, as shown by the irregular decayed spots within the substance of the teeth. Renault's work covered many geological periods later than the Coal Measures, and his large monograph is the summing up of twenty-four years of activity spent in investigating the nature of the *Microorganismes des combustibles fossiles* in peat, lignite, bituminous schists (in which he found rhizopods, bacteria, and fungi), boghead coal, cannel, ancient schists, and the silicification of organisms in very ancient rocks. Renault's work is of great importance. A few of his figures are given herewith (Fig. 2). The bacteria take the form of coccoids, bacilli, diplococcoids, and micrococcoids. Often in sporangia of the early cryptogamous plants Renault found natural cultures of bacteria which have been preserved by silicification. These organisms, which have been made so well known by the studies of French scholars, may all of them have been non-pathogenic forms, but the possibility of their being the cause of the disease of succeeding forms of life is very evident, and they should be mentioned as possible sources of disease.

PERMIAN

The great Permian period, with its widespread development of curious reptilian forms, has furnished us with the first evidences of traumatic conditions as they prevailed among the early forms of vertebrate life. Fractures may have occurred earlier than the Permian, but they have not yet been seen. The oldest known fractures are found among the reptiles from the Permian of Texas. A left radius of *Dimetrodon*, a primitive reptile, presents a well-marked case of fracture (Fig. 6) with subsequent healing, although there is still some intermediary callus. An attempt to study the nature of this fracture by means of the X-ray has not resulted in any new knowledge. The fracture runs directly across the bone, as do all the early cases of fracture

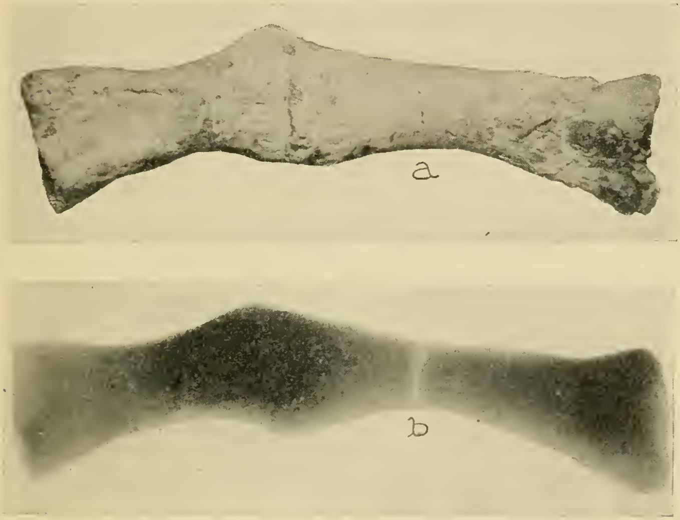

Fig. 6.—The oldest known fracture. It is a simple transverse break of the radius of *Dimetrodon*, a long-spined reptile from the Permian of Texas. The injury healed with some callus, indicating a slight amount of mechanical irritation, but no infection. The bone was solid, as were the majority of ancient reptilian bones, and this doubtless determined the nature of the fracture. *a*, photograph of the radius, showing nature of injury; *b*, X-ray picture of the bone. The light line is a postfossilization break. On account of the impregnation of minerals, little of the pathology can be determined. (Specimen in Walker Museum, University of Chicago.)

among animals with solid limb bones, and the resulting callus produces a decided enlargement of the bone around the fracture.

A small fragment of a fractured rib, from the same beds in which there was quite an old callus, has been studied microscopically. The callus was quite evidently an old one, for the fracture was completely healed. A study of the microscopic section proves this to be true, since evidences of osteosclerosis and osteohypertrophy are clearly evident. The region near the spicule of bone is regarded as due to osteosclerosis, which is interpreted on the basis of the presence of a heavy deposit of calcium salts and the absence of osseous trabeculae. The white band running vertically may be interpreted as a spicule of bone due to the splitting of the rib. The hypertrophied area to the right of the osseous band is often seen in old calluses and is interpreted on the basis of the presence of numerous trabeculae of bone. There is no evidence that the fracture was infected, necrotic sinuses being entirely wanting.

TRIASSIC

Except for occasional specimens of fossil fishes and other forms preserved in the pleurothotonos and opisthotonos, attitudes suggesting a condition of spastic distress, little is known about the pathology of the animals which lived during the Triassic. There doubtless is much to learn in the future, since many vertebrate species are known from this period.

JURASSIC

The Jurassic of England furnishes the first evidences of necrosis, and a suggestion of metastasis is seen in the pathological nature of the bones of *Metriorhynchus moreli* Desl., a crocodile described by Erwin Auer from the Oxford Clay.

The skeleton of this interesting animal was only partially preserved. There are evidences of pathology in the palate, on the two femora, on a sacral vertebra, and on the pelvis. Auer says:

> On the middle of the inferior side of the palatine is a section that is unusually differentiated by cavities, and consists of fossulae, a condition that is not otherwise encountered in crocodiles, and that doubtless is connected with the pathologic deformities the bones exhibit.
>
> The right femur is normally formed, but it displays below the caput femoris a peculiar corrosion, and the condylus internus is reduced at the distal end.

The left femur departs in form quite considerably from the normal type. The head of the bone has undergone a significant contraction, and the formerly globular articular surface is deformed. Under the head of the bone the femur exhibits an abnormally small diameter, and on the external side of the bone a ridge is raised.

The sacral vertebrae also exhibits significant deformities of a pathologic nature; the body of the vertebra is noticeably thickened, irregularly jagged on the outer side, and set with numerous rather deep holes. The body of the vertebra is completely hollowed out from the end surface.

The description indicates the presence of a tuberculous or similar necrosis of the bones and is the most complete example of a seriously diseased vertebrate which has been seen in the fossil condition.

COMANCHEAN

The gigantic dinosaurs of the Comanchean have long been known to have suffered from disease and injury. These have been described sufficiently well in other places to make their characters known. The most interesting lesion seen among the dinosaurs has been regarded as resembling a modern hemangioma (Frontispiece). A sawed section through the fossil tumor shows the nature of the vascular spaces and the arrangement of the osseous trabeculae is seen in a sagittal section of the mass.

CRETACEOUS

The diseases of the mosasaurs may be taken as samples of the prevalence of disease and injury among the vertebrates of the Cretaceous. These aquatic vertebrates, as well as their congeners, the plesiosaurs and dinosaurs, were afflicted with a variety of diseases and the writer has been able to study the details of the lesions on the fossils from the Cretaceous of Kansas. Twenty years ago Williston called attention to the diseased nature of the arm bones of one of the Cretaceous mosasaurs. Recently I have been able to study these bones (Fig. 7). Their pathological nature and the exostoses of a hyperplastic nature are at once evident. A tentative diagnosis of osteoperiostitis has been given as the cause of the lesions. Microscopic study of the lesions reveals the bony lamellae laid down in a concentric manner, as if to form Haversian systems. The lacunae are relatively large and are provided with short canaliculi, and there are areas where osteoid tissue is present, comparable in every way with osteoid tissue seen in modern cases of osteomyelitis. For the first time in the history of paleohistology, perforating fibers of Sharpey are seen running through the sections.

A dorsal vertebra of *Platecarpus*, a well-known mosasaur from the Cretaceous of Kansas, presents an extremely interesting example of an osteoma (Fig. 9), the only one thus far known in a fossil condition. The specimen has been studied microscopically, and a gross examination of a sawed section through the osteoma and vertebra shows in a very interesting manner how the

FIG. 7.—An example of Mesozoic pathology seen in the flat exostoses developed on the humerus of a mosasaur, an aquatic reptile, from the Cretaceous chalk of western Kansas. The pathology has been diagnosed as that of osteoperiostitis, with arthritis deformans, indicated by the lipping of the joint surfaces. The bone, though flat in its fossilized condition, was more rounded in life. Normal bones have smooth surfaces. The pathological excrescences indicate the presence of bacteria or other irritant under the periosteum. Microscopically the osseous outgrowths differ from normal bone.

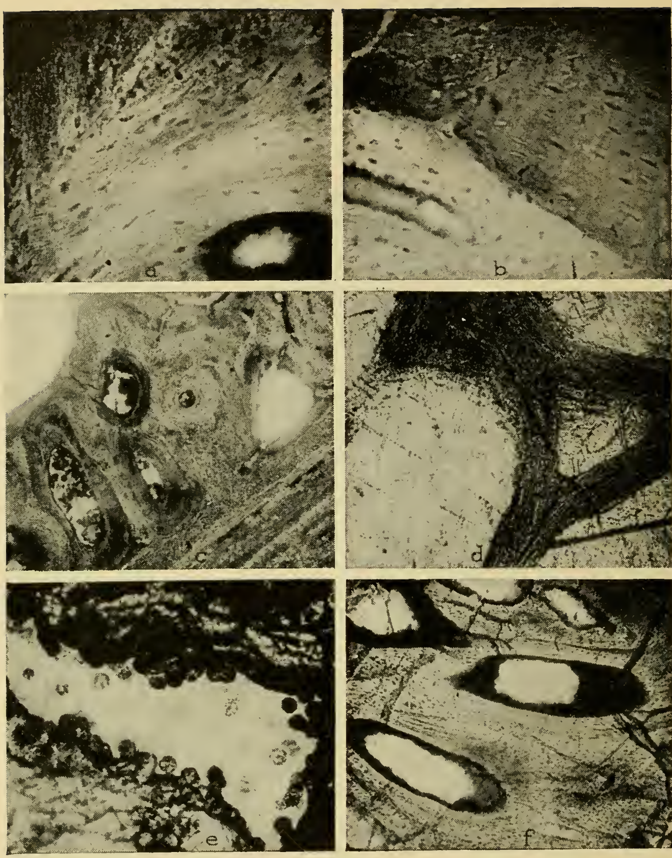

Fig. 8.—Photomicrographs of various fossil pathological and normal bone, showing microscopic anatomy of bony parts. Figures represent Comanchean and Cretaceous vertebrates. *a*, High-power photomicrograph (600 diameters) of a giant dinosaur bone, showing the general arrangement of the osseous lamellae and lacunae around the vascular canal, which is represented by the oval black spot in the lower right-hand corner. *b*, Section of the same bone in another situation, showing a distinctly distorted lacunae near the upper right-hand corner, due to the invasion of bacteria. Dinosaur bones are largely osteoid in nature, indicated in the present instance by the wide, structureless spaces between the lacunae. *c*, Haversian systems are not usually present in Mesozoic bones, but the present case shows the influence of pathology on the formation of such structures. An exceptionally good system is shown near the center of the picture. *d*, A section of the Cretaceous osteoma, showing in the light spaces the huge vascular spaces separated by the narrow, dark, fibrous bands of bone. *e*, The round objects on the border of the light area in the center of this picture are supposed to represent fossil blood corpuscles of a giant dinosaur. *f*, histology of the Hemangioma shown in the Frontispiece. The six light areas with black borders are vascular spaces.

tumor mass grew out of the vertebra. An X-ray examination of the bone reveals nothing of importance.

FIG. 9.—A Mesozoic osteoma, the oldest known, seen on the dorsal vertebrae of *Platecarpus*, a Cretaceous mosasaur from western Kansas. The osteoma is a definite outgrowth from the body of the bone; natural size.

A radius of another mosasaur shows on the proximal surface an extensive necrosis. Sections of the bone show hypertrophy of the peripheral substance. The nature of the organism producing the necrosis is not determined, but the fossil presents an exact duplicate of modern instances of extensive arthritic necrotic sinuses, which result in hypertrophy and the production of numerous osteophytes.

Dollo has described dental caries in a mosasaur jaw, with a hyperplasia of the bone and accompanying necrosis, as if the creature had suffered from a mouth infection similar to modern alveolar pyorrhea. The results of pyorrhea are identical in modern and ancient bones.

The prevalence of disease reached a climax in the mosasaurs, dinosaurs, plesiosaurs, and turtles of the Cretaceous, and with the opening of the Tertiary the incidence of disease went sharply down, to rise again with the rise of mammalian life and reach a very high point during the Pleistocene.

EOCENE

The extinction of the large groups of reptiles at the close of the Cretaceous doubtless brought about the disappearance also of many forms of disease which attacked these animals. Some forms of disease, as seen in the lesions left on the fossil bones, were persistent in the case of caries and alveolar osteitis with the associated forms of necrosis. It is to be expected that the paleontological evidences of disease would be rather scanty during the Eocene and in fact not a great deal is known. One interesting indication of a pathological condition may be seen in the tibia, fibula, and associated tarsal bones of *Limnocyon potens*, a creodont carnivore from the Washakie Eocene. These bones show considerable exostoses and hypertrophy indicating an infection of some duration. The appearance of the bones suggests modern conditions of nutritional disturbances resulting in the softening and lightening of the bones as in osteomalacia.

OLIGOCENE

The mammals of the Oligocene suffered from disease and injury, though not so greatly as their successors, nor were any of the diseases prevalent at that time of sufficient importance to produce extinction. It must be remembered, however, that paleontological evidences of the antiquity of disease deal with hard parts exclusively, the soft parts known not being pathologic. The Oligocene dog, *Daphaenus felinus*, so carefully and beautifully described and figured by Hatcher, presents on the inferior portion of both radii a symmetrical tumor-like mass, the only example of duplicate exostoses in fossil animals. The nature of the exostosis is problematical and I have not been able to find a parallel for this condition among the lesions on human bones. An excellent example of fracture with resulting callus formation and a splendid pseudarthrosis is known in a rib of the right side of *Titanotherium robustum*, a perissodactyl from the White River beds of South Dakota. A careful account of this interesting fracture has been given, accompanied by a detailed illustration of the callus.

MIOCENE

As an example of the nature of disease during the Miocene may be mentioned the lower jaw of *Merychippus campestris*, a three-toed horse from the Loup Fork beds of South Dakota. One ramus of the jaw has a prominent swelling indicating the presence of a long-standing infection, possibly actinomycosis in its early stages, before the eruption of the bone took place. Alveolar osteitis with the formation of some osteophytes, resembling the results of pyorrhea, are also seen.

PLIOCENE, PLEISTOCENE, AND RECENT

The pathological conditions found among the mammals of the Pliocene, Pleistocene (Fig. 10), and Recent

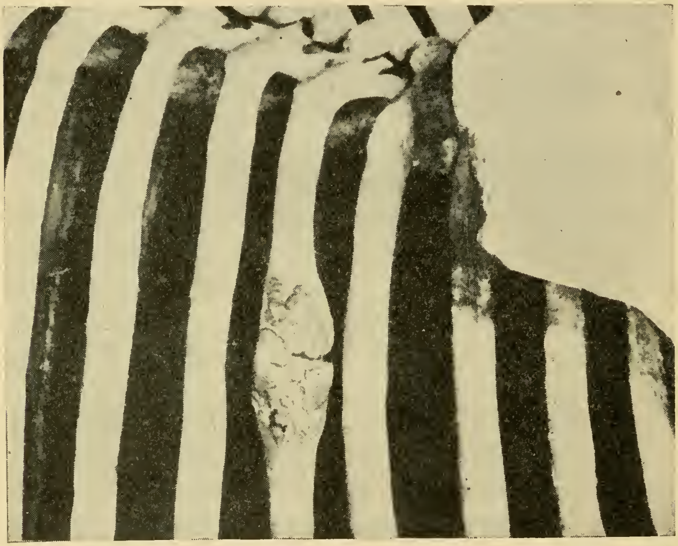

Fig. 10.—Fractured rib, with a pseudarthrosis, in a skeleton of the American mastodon. (Yale University.)

geological periods were the first known and have been extensively described and studied by a number of writers from Esper (1774) to Virchow (1895). There are about twenty contributions dealing with the diseased nature of bones from these periods. A review of our knowledge, especially of the pathology of fossil man, has been given elsewhere and little need be said here concerning the pathological evidences from these periods. A few examples of diseased and injured bones from the Pleistocene, Rancho la Brea beds of southern California shown in Figure 11, will give an idea of the prevalence of disease in the bones from these periods.

The foregoing brief summary of paleontological evidences shows that in each geological period there are a few evidences of pathological processes known, although there there has been no organized search made for diseased remains. In fact, paleontologists as a rule have paid very little attention to evidences of pathology in fossil remains, though the subject is one which yields much that is interesting. The subject increases our vision as to the possibilities of medical history and extends our knowledge of the occurrence of disease back into geological time for many millions of years. No new ideas of pathology have been seen in the study of these ancient lesions—nor were they expected. Since the organization of animal and plant forms of ancient times differs only in minute details from those of recent times, there is no reason why we should expect new forms of pathology. Doubtless many of the lesions described will, on closer examination, prove to be lesions of extinct diseases. We know from medieval history that diseases do become extinct, and possibly many of the diseases from which ancient animals suffered are now extinct. Their results, however, as seen in the fossilized bones, closely parallel the pathological anatomy of recent times.

The question of extinction is still an open problem. A study of the paleontological evidences of diseases, as seen in the bone lesions, does not help us much yet in an appreciation of what part disease may have played in extinction. The part may have been great, but this is a hypothetical assumption, based purely on analogy.

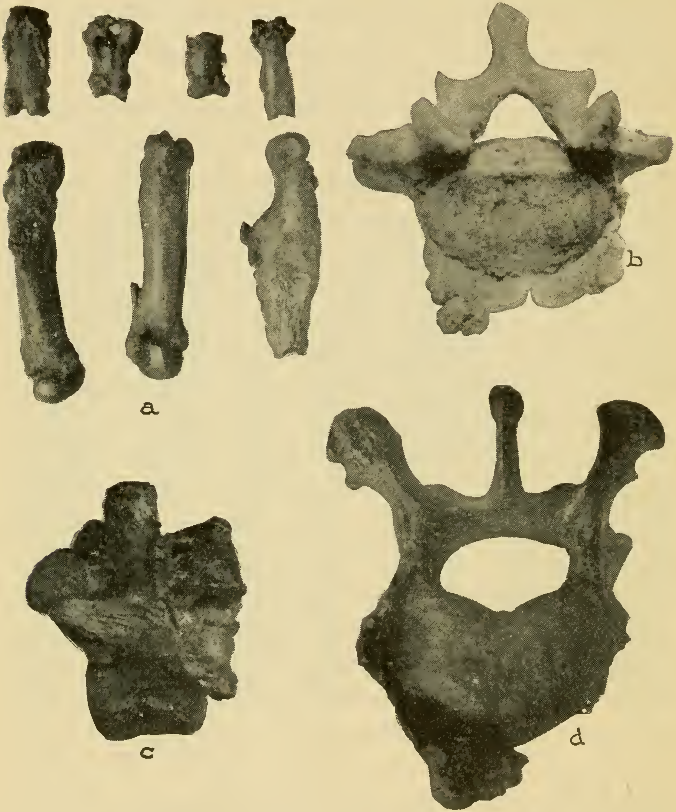

FIG. 11.—*a, c,* and *d,* are fossil Pleistocene bones from the Rancho la Brea beds of southern California, showing pathological lesion. *a,* seven phalangeal bones of wolf showing results of arthritis, osteomyelitis, and fracture with accompanying callus and osteophyte. The second figure in the top row is the example showing the result of osteomyelitis. The necrotic processes had left merely a shell of bone. *b,* Modern human lumbar vertebra showing a widespread lesion of spondylitis deformans for comparison with the fossil bone showing a similar lesion in *d. c,* Vertebra of saber-toothed cat, showing pathology seen in the hypertrophy in the upper right-hand portion. *d,* Lumbar vertebra of *Smilodon,* a giant saber-toothed cat, showing lesions of spondylitis deformans. There appears to have been an extensive lesion, extending on to several vertebrae. The articular surfaces are normal, the pathology being confined to the marginal lipping characteristic of this disease in man.

TABLE OF GEOLOGICAL EVIDENCES OF DISEASE

(Modified from Schuchert)

Eras	Geological Periods	Evidences of Disease	Animal and Plant Life
Psychozoic	RECENT	Diseases of the ancient Egyptians; the pre-Columbian Indians of North America; the Incas of South America and Neolithic man of Europe Extinct mammals	Rise of world-civilization Age of man Domesticated animals
Cenozoic	PLEISTOCENE	Spondylitis deformans on cave bears; fracture and callus; necroses; caries in mastodon; osteomyelitis; exostoses on femur of Pithecanthropus	Paleolithic man in Europe; world-wide extinction of great mammals; period of glaciation; transformation of man-ape to man
	PLIOCENE	Spondylitis deformans; actinomycosis in a rhinoceros	Ancient types of horses; many groups of extinct mammals
	MIOCENE	Fracture and callus; hypertrophy; actinomycosis; dental caries; pyorrhea; necrosis	Culmination of mammals
	OLIGOCENE	Fracture and callus; tumor	Rise of higher mammals
	EOCENE	Dental fistula; necrosis; osteomalacia; ankylosis	Introduction of higher mammals; vanishing of archaic mammals; introduction of grasses
	EPI-MESOZOIC INTERVAL OF UNCERTAIN LENGTH		Rise of archaic mammals
Mesozoic	CRETACEOUS	Osteoma; exostoses; fracture and callus; dental caries; necrosis; hypertrophy; arthritides; alveolar osteitis; pachyostosis; osteoperiostitis; opisthotonos	Extinction of great reptiles; extreme specialization of reptiles; small mammals; toothed birds; large, bony fishes; deciduous trees
	COMANCHEAN	Hemangioma; arthritides; necrosis; opisthotonos; fracture with callus; parasitism	Giant reptiles; rise of flowering plants; small mammals
	JURASSIC	Opisthotonos; pleurothotonos; suppurative necrosis in crocodile; indication of metastasis	Rise of birds; flying reptiles; small mammals; first turtles; ganoid fishes
	TRIASSIC	Opisthotonos; pleurothotonos; fracture and callus; necrosis	Rise of dinosaurs; archaic reptiles; labyrinthodonts; fishes

TABLE OF GEOLOGICAL EVIDENCES OF DISEASE—*Continued*

Eras	Geological Periods	Evidences of Disease	Animal and Plant Life
	EPI-PALEOZOIC INTERVAL OF UNCERTAIN LENGTH		Extinction of ancient life
	PERMIAN	Oldest known callus and fracture; caries in fish bone; bacteria; osteomyelitis	Modern insects; archaic reptiles; armored amphibians; scaled fishes; periodic glaciation
	PENNSYLVANIAN	Myzostomid parasite in crinoid stem; first tumor, fungi bacteria	First reptiles; numerous amphibians; first bony fishes; insects; rise of land floras
	MISSISSIPPIAN		Amphibian footprints; rise of ancient sharks
	DEVONIAN	Parasitism	First footprints of land vertebrates; first land floras; dominance of armored fishes; insects; lung fishes
PALEOZOIC	SILURIAN	Communism	First air-breathers (scorpions); lung fishes; fresh-water fishes; starfishes; giant arachnids
	ORDOVICIAN	First recorded traumatism	First armored fishes; corals; nautilids; dominance of trilobites; 5,000 species of invertebrates known; rise of shelled animals
	CAMBRIAN	Communism; beginnings of dependent life	1,000 species of invertebrates; first known marine faunas; brachiopods; trilobites; corals; sponges; protozoa; molluscs; algae; no land plants
	EPI-PROTEROZOIC INTERVAL OF GREAT DURATION		

TABLE OF GEOLOGICAL EVIDENCES OF DISEASE—*Continued*

Eras	Geological Periods	Evidences of Disease	Animal and Plant Life
PROTEROZOIC	ALGONKIAN	No known evidences of disease	Age of primitive marine invertebrates; oldest known fossils; worms; radiolaria; bacteria (non-pathogenic)?
	NEO-LAURENTIAN		No fossils known
ARCHEOZOIC	PALEO-LAURENTIAN		No definite evidences of life; limestone deposits may be some indication of biological conditions. This period witnessed the origin of life and the beginning of the world

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CHAPTER IV

CERTAIN EXAMPLES OF FOSSIL PATHOLOGY

Osteomyelitis in the Permian
Vertebrae of a Dinosaur Exhibiting a Pathological Lesion
Spondylitis Deformans in the Dinosaurs
Spondylitis Deformans in Eocene Mammals
An Ankylosed Elbow Joint in an Eocene Mammal
A Subperiosteal Abscess
American Cave Bears
Pathology of the Clam
Caries
Regeneration
Necrosis
Fractures
Multiple Arthritis in a Mosasau
Opisthotonos
Mesozoic Pathology

There have been so many examples of tossil pathology made known that it will not be possible to discuss them all in this small volume. Selections have been made of the more striking cases of disease or injury which will serve to give a conception of the wide range of pathological processes in operation during the lifetime of the fossil vertebrates. That these evidences, abundant as they are, are only a small fraction of disease as it really existed in geological time will be apparent when we consider that all the examples described below are diseases or injuries of hard parts, shells, or bones. The number of modern diseases afflicting the skeleton, compared to those which attack the soft parts and hence leave no trace, is very small. Doubtless a similar proportion has prevailed since early geologic time. We thus see merely traces of the pathology of fossil animals. To this factor we must add the small number of animal remains as compared to those which must have existed, as well as the small fraction of recovery of those whose remains were fossilized.

Such examples of pathology as are given furnish not only light upon the nature of Mesozoic pathology, but give an insight into the life-histories as well. When a sluggish Permian reptile was so unfortunate as to fracture his femur, we are led to conclude from the manner in which the injury healed that the animal sought quiet and refrained from either acquiring an infection or producing callus by aggravating the wound. Such fractured Permian bones as are known have healed in a manner (Fig. 6) to bring joy to any surgeon. The lesions are always direct transverse breaks, because, I suppose, of the solid nature of the bones of these creatures. If they were sluggish, as we suppose they were, it must have taken considerable time for the new bone-forming osteoblasts to function to an extent to permit movement. Their very sluggishness would obviate any necessity of food over a period of time. In this way, probably, we may account for the unusually perfect healing of the early reptilian bones. A certain giant dinosaur, when he broke a rib, was not so cautious, and as a result left a large callus surrounding a simple transverse fracture.

When the lesions are infected, as many of them were, we learn of the activity of bacteria in new situations. While we may not always succeed in recovering the ancient pathogenic bacteria, they have nevertheless left indubitable evidences of their activity. Such examples indicate a wide range of necrotic processes, ranging from dental caries to osteomyelitis. Some of the necroses may be evidences of injuries received during the pairing season, as Abel suggests, when the males actively contended with each other for mates.

The lesions described below are all skeletal in nature. So rarely are soft parts of fossil vertebrates found that when discovered they constitute paleontological gems, and none so far seen exhibit any pathological evidences, and many of them are so perfectly fossilized as to retain their original cellular morphology.

OSTEOMYELITIS IN THE PERMIAN

It is always an interesting matter to be able to call attention to the earliest appearance in geological time of any phenomenon of nature which is common at the present time. It is especially important in ancient pathology to point out the similarity in form of the results of infective processes of ancient times with those of recent epochs. It is evident that the results of pathological processes have undergone no particular evolutionary change, and one untrained in the study of fossil objects is able to recognize an example of osteomyelitis from the Permian if he is acquainted with modern pathology.

The specimen which shows this interesting phase of pathology is a posterior dorsal spine of a reptile of the *Dimetrodon* type and was collected in the Red Beds of Texas by Mr. Paul C. Miller, of the University of Chicago. The spine had been fractured near its base in a simple transverse break, the line of which is still evident, and from an ensuing infection a chronic osteomyelitis developed in the shaft of the bone, producing a sinus-filled tumefaction which is today so characteristic of that condition. This argues for the presence of infective bacteria during the Permian, such as have

Fig. 12.—Photograph, enlarged ten diameters, of a cross-section of one of the dorsal vertebral spines of *Dimetrodon*, a long-spined reptile from the Permian of Texas, showing the effects of osteomyelitis in the arrangements of the osseous trabeculae around the large necrotic sinuses, filled with pus during the infected period and now preserved by calcite crystals. The infection was a mild one compared to the virulent infection shown in Figure 36 (p. 141) from the American bison.

been demonstrated by the magnificent researches of Renault in the Paleozoic of France.

This is the oldest vertebrate fossil showing the results of infection which has been seen or described (Fig. 12), as it is likewise the oldest example of osteomyelitis. These statements apply only to fossil vertebrates for I have not sufficient knowledge of invertebrate fossils to make a sweeping statement covering all fossil forms, but so far as my studies go I have seen no example of bacterial infection during the life of any Paleozoic animal older than the reptile referred to above. This, of course, brings up the question as to the existence of a very mild form of pathology during the early geological periods.

VERTEBRAE OF A DINOSAUR EXHIBITING A PATHOLOGICAL LESION

The assistance which paleontology may render students of disease is instanced by the following discussion of a pathological lesion involving two caudal vertebrae of a sauropodous dinosaur from the Como beds of Wyoming. The lesion has the appearance of a spongy growth surrounding the intervertebral articular surfaces, and involving the spinous processes of two caudal vertebrae. The normal form of the vertebrae is well known and the large amount of pathological growth is evident. The mass resembles closely (Frontispiece) the tumor-like masses of oak trees. It entirely encircles the vertebrae and has involved fully half of the two bones. All evidence of separate structure is obliterated and the vascular canal of the chevron has been filled by the bony matter, and the chevron has been pushed far out of its normal position.

The specimen has a length of 26.5 centimeters and a weight of 5.1 kilograms. The circumference of the normal articular surface is 27 centimeters, and the same measurements around the middle of the tumor-like mass is 38.5 centimeters. The surface of the lesion is rather deeply pitted, and the mass is asymmetrical, having attained greater dimensions on one side than on the other.

The enlargement is somewhat suggestive of the lesion of chronic osteomyelitis. It may be a callous growth due possibly to a fracture of the caudal vertebrae; or it may be a bone tumor, such as a *hemangioma*. Its nature is of course uncertain, but it is an interesting thing that in the Comanchean pathological processes should have produced results which are to all appearances the same as occur today.

SPONDYLITIS DEFORMANS IN THE DINOSAURS

Coalesced vertebrae have been frequently seen, described, and figured in the skeletons of the huge land reptiles of the Mesozoic, and Osborn especially has referred to them as being the resting-point of the tail. Coalesced cervicals are known in *Camarasaurus*, *Diplodocus*, and *Tyrannosaurus*, and doubtless close scrutiny of the known material would reveal the lesions elsewhere in the body. The condition was extremely puzzling until a series of five caudals of *Diplodocus* were studied in the American Museum of Natural History. A fortunate postfossilization fracture revealed the unaffected articular surfaces of the vertebrae in two places and showed the ringlike growth of the lesion, similar in all respects to the modern advanced cases of spondylitis deformans, seen so commonly in mammals and in man. Ruffer has reported a case of spondylitis from a Miocene crocodile of Egypt, so the disease is not unknown among reptiles. Its age, however, is greatly extended by the recent observations, and it is probable that further study will carry the antiquity of this peculiar pathological condition far back into geological time.

SPONDYLITIS DEFORMANS IN EOCENE MAMMALS

Definite evidences of similar pathology were observed in two small mammals from the Eocene, one being in the tail, and the other in the anterior dorsal region. The lesions are so similar to those of human pathology that additional descriptions are unnecessary. No evidences of the incipient lipping were definitely observed, though it was suggested in a number of cases. The lesions may not have followed the same method of formation in ancient times which they follow now.

AN ANKYLOSED ELBOW JOINT IN AN EOCENE MAMMAL

A small, primitive, five-toed ungulate from the Eocene, known as *Ectoconus*, had in life suffered a fracture of the left humerus immediately above the condyles, resulting in the coalescence of the articular end of the humerus in the olecranal fossa. A pseudarthrosis was formed between the fractured end of the humerus and the radius particularly, though some new joint surfaces occurred also on the ulna. The joint surfaces were dense and eburnated, recalling in their ivory-like consistency the eburnated surfaces in joint lesions of the so-called rheumatoid arthritis. The fracture had evidently been extremely septic, for the whole lateral surface of the ulna is pitted with necrotic sinuses and roughened with carious bone. In fossilization the bones were all crushed flat, so a detailed study of the joint lesion would not reveal a great deal more than is shown in an external examination. This is the oldest known ankylosed elbow, with an antiquity of millions of years.

A SUBPERIOSTEAL ABSCESS

The limb bones of the huge dinosaurs of the Mesozoic were seldom fractured because of their great size and strength. A single limb bone of one of the largest animals has a length of 6 feet and a weight, as fossilized, of about 700 pounds. But one of the horned dinosaurs of the Edmonton Cretaceous, discovered by Barnum Brown, has suffered an oblique fracture of the humerus which healed in a very bad way, resulting, as Mr. Brown said, "In the sickest fossil bone I have ever seen." On the anterior surface of the bone the periosteum had doubtless been greatly elevated by an ingrowth of callus, which later ossified into a bridge of bone connecting the lower articular surface with the enormous deltoid crest, and covering an enormous abscess, capable of holding several liters of pus.

AMERICAN CAVE BEARS

Virchow, Mayer, Esper, Schmerling, and the other founders of paleopathology did their initial observations on the diseased bones of cave bears of Europe. Esper, in 1774, initiated the subject by describing what he took to be an osteosarcoma on the femur of a cave bear. It is extremely interesting then to observe in the United States National Museum, in a collection of mammalian fossils from the Cumberland cave deposit of Maryland, diseased bones of a large American cave bear. A right femur shows on the lower posterior surface a wide area of carious roughening, with low, blunt osteophytes.

A skull of an ancient pig shows similar carious patches on the left mastoid. This collection, soon to be described by Dr. J. W. Gidley, will add much to our knowledge of disease in the American Pleistocene.

PATHOLOGY OF THE CLAM

In the Miocene of the eastern states there occurs a large species of clam, known to paleontologists as *Venus tridacnoides*. The shell is immensely thickened and very heavy. Dr. Gilbert Van Ingen, of Princeton, to whom I am indebted for calling my attention to this species, regards the form as a pathological race of *Venus Rileyi*, a normal clam occurring in the same beds. Thickening in the tests of ancient invertebrates, simulating osteo-hypertrophy in vertebrates, is fairly common. A careful study of this pathological clam has resulted in interesting data.

CARIES

I nave stated elsewhere that caries of the teeth is fairly common among fossil vertebrates, yet a careful investigation into the matter reveals the interesting fact that it seems to be the rarest form of pathology in ancient times. It is true that Dollo in the mosasaurs, Renault in fishes, and Leidy and Hermann in the mastodon have described this form of pathology, yet it seems not to be common. Experienced collectors of fossil mammals have never seen a carious tooth. In one of my papers, on the basis of the appearance of the photograph, I figured what I took to be a carious spot in the lower premolar of a three-toed horse. Examination of the specimen, however, reveals the fact that the defect is a postfossilization fracture and is not due to disease.

Mr. Anderson, at the American Museum, showed me some thin sections of a tusk of *Mastodon obscurus* which showed undoubted carious spots along the edge of the dentine. The pathology is, however, not common.

REGENERATION

This phenomenon is essentially not pathological, but that it often follows traumatism is my excuse for mentioning it here. Mr. Frank Springer, at the United States National Museum, showed me some Silurian crinoids which had apparently had an arm broken or bitten off, and in the process of regeneration often two arms took the place of the lost one, the regenerated arms being usually smaller than the normal ones. Mr. A. H. Clark, of the same institution, has lately made a study of the pathology of recent crinoids and his results are incorporated in Volume II of his *Monograph of Existing Crinoidea.*

NECROSIS

The huge glyptodonts of the Pliocene and Pleistocene of South America, in spite of their heavy armoring of bone on skull, body, and tail, were often subjected to injuries which became infected and produced extensive necroses in the bony carapace. Dr. Sinclair, of Princeton, suggests that these necrotic sinuses were caused by injuries from the saber-toothed cat which in attacking the glyptodont, and finding himself baffled by the bony armor, clawed and bit the carapace of the beast. If the giant Pleistocene cat's teeth and claws were as septic as the modern house cat's are reputed to be, sepsis may well have followed such an attack. Similar necrotic sinuses were seen in the dermal plates of the giant dinosaur, *Stegosaurus* (Fig. 13), which bore a huge armament above his vertebral column.

FIG. 13.—A portion of one of the dermal plates of the armored dinosaur, *Stegosaurus*, preserved in the United States National Museum. An infected area is evident in the several sinuses which have been eaten out of the solid bone by bacterial action. The infection doubtless arose as the result of a slight injury and furnishes undoubted proof of the presence of infective bacteria in the Cretaceous. The margins of the sinuses are well rounded, indicating that the wound had healed before the death of the animal.

FRACTURES

This form of traumatism is extremely common among fossil vertebrates, more so in some forms than in others. Nearly every modern phase of fracture is to be seen among ancient animals, the form of the skeleton, of course, modifying the pathology. A skull fracture, for instance, in an ancient phytosaur, a long-snouted, crocodile-like creature (Fig. 14), would not be of the same nature as a skull fracture in man. Fractures are

FIG. 14.—Skull of a long-headed reptile, *Mystriosuchus*, from the Triassic of Germany, showing the oldest known skull fracture. The injury is anterior to the nares and was badly infected, though healing with the formation of much callus and many necrotic sinuses, which are especially evident on the palate of the skull. The large anterior muscular eminence looks like a callus following fracture, but the true injury is further posterior indicated by the star (after von Huene).

especially common in the skeletons of *Moropus*, a heavy, clawed ungulate of the Tertiary, with much the appearance of a horse, though the fore limbs are longer than the hind, and provided with huge claws. These Chalicotheroidea must have had a pugnacious disposition, for they suffered many severe fractures of the skeleton. There are many dozens of fractures evident among five or six thousand bones of this genus. Fractures in this animal are interesting to the paleontologist as indicating something of the habits of life of the animals; but to the medical man the fractures are interesting in the form of pathology which is evident. Fractures in the skeleton of this beast will be described and illustrated in the forthcoming treatise on paleopathology.

MULTIPLE ARTHRITIS IN A MOSASAUR

Mr. H. T. Martin, of the University, of Kansas has loaned me for study a nearly complete series of the left hallux of a large mosasaur, *Platecarpus*, from the Cretaceous of Kansas, showing extensive arthritic lesions in all the joints of the toe. The metatarsal is especially pathologic, flattened, shortened, necrotic, with the articular ends of the phalanges lipped, similar to the lipping observed in arthritis in human skeletons. This is the first known example of multiple arthritis in a fossil vertebrate. The primary lesion was doubtless at the metacarpotarsal junction. Whether the other lesions are to be regarded as metastases is uncertain. Microscopic study of the lesions will be made, and the specimen will be more carefully described and illustrated later.

OPISTHOTONOS

Past events can only be interpreted in the light of recent phenomena, and to this rule, first so clearly outlined by Sir Charles Lyell, the writer was adhering when he proposed the interpretation that the attitude of fossil vertebrates often suggested spastic distress and induced an inquiry into the causes of their death. Bashford Dean especially has criticized this interpretation and suggested an alternative, voicing not only his opinion, but the sentiments of other paleontologists. Opisthotonos cannot be regarded as a phenomenon restricted to the human race, but the phenomena, opisthotonos, pleurothotonos, and emprosthotonos are extremely common among modern vertebrates of all classes, as well as in the mollusks. Laboratory animals are often found fixed in this attitude by the *rigor mortis*. Rabbits, guinea pigs, dogs, frogs, and other laboratory animals frequently exhibit the phenomena. The phenomena occur among modern vertebrates in the order of frequency named, as they do also among fossil vertebrates. It was the similarity of these occurrences which first suggested that these phenomena might indicate disease among fossil vertebrates (Fig. 15).

There is no medical literature bearing on this problem, partly because the phenomena are so commonly seen that medical writers have not deemed it worth while. However, Cushny in his textbook of pharmacology has figured a rabbit in opisthotonos, and most medical works on nervous diseases mention the phenomena, but to date none have discussed it.

It is easy to see that the pull is exerted by the muscles and tendons, and the reason why opisthotonos is the more commonly seen is that the muscles of the neck are strongest. In this spastic condition all the muscles of the body are intensely contracted and the more powerful muscles overcome the resistance of the weaker ones. It is interesting to observe in this connection that in the arm muscles of the male frog the flexors overcome the extensors and flex the arms into the attitude of embracing, while in the female frog the extensors overcome the flexors and the arms stick out straight, while in a spastic condition. Occasionally, however, as in pleurothotonos, the lateral muscles overcome the dorsal ones. The ligaments of the vertebral column are but slightly elastic. If the ligaments did cause this phenomenon then the head should be pulled the other way, for the ventral ligaments drying first would overpower the dorsal ones. Sheep, cattle, and horses are commonly seen dead in this position on

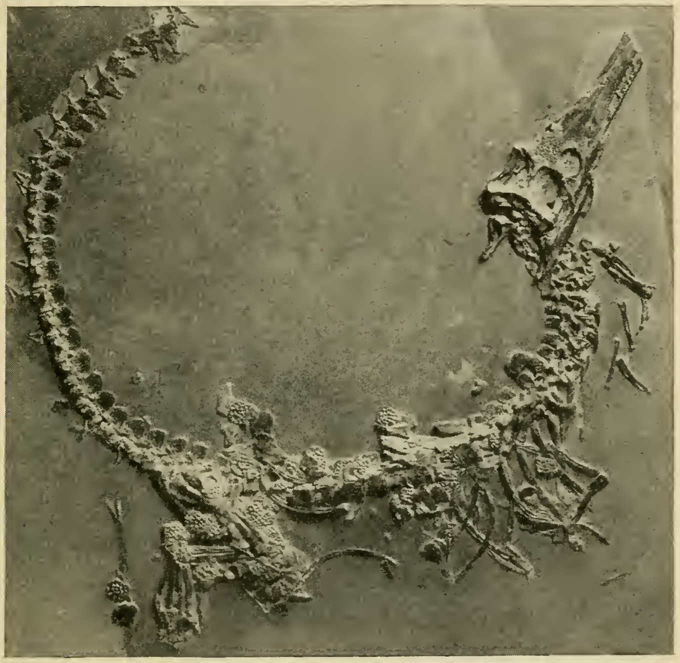

FIG. 15.—Skeleton of an ancient teleosaur, a crocodile-like reptile, known as *Steneosaurus bollensis*, from the Jurassic of Germany, as mounted in the United States National Museum. The specimen shows the opisthotonic attitude, suggestive of spastic distress. The head is thrown far backward and the tail is drawn upward, as if the muscles were in a violent contraction at the time of death. Similar attitudes in modern vertebrates follow neurotoxic conditions.

the western plains, but no one can prove that the drying or rotting of the ligaments caused the attitude, while it is easily and daily proved that they died in a spastic condition, in opisthotonos.

Opisthotonos and its related phenomena cannot be rightly regarded as a special form of disease, but rather as a result accompanying many forms of disease and poisoning.

Another important phase of the matter, and a more difficult one, is that vertebrate fossils are not always figured and studied in the positions in which they died. They are subject to so many disturbing agencies, wind, water, and predatory animals, that we cannot be sure that the position is really the one in which they died. Often the limbs and parts of the body are shifted in preparing for museum exhibition. A sufficient number of animals have been discovered in an undisturbed position to warrant the conclusion that some of the vertebrates preserved in the opisthotonos were the victims of disease. The beautiful skeleton of *Steneosaurus bollensis* (Fig. 15), in the United States National Museum, exhibits one of the most interesting examples of this known.

MESOZOIC PATHOLOGY

The subject of paleopathology is replete with pitfalls. When one recalls that the field covers all evidences of disease or injury from the Proterozoic to the civilization of the continents by the white races, the reasons for the pitfalls will be evident.

The difficulties arise on every hand. First, paleopathology is "dry-bone pathology," a subject held in some contempt by medical men, and in consequence the literature on the subject is widely scattered. One thus needs to build up a knowledge of modern human and animal pathology relating to the skeleton. Second, the determination of disease and its pathology in modern medicine is by microscopic (Fig. 16), as well as by gross examination. Hence a knowledge of the histological

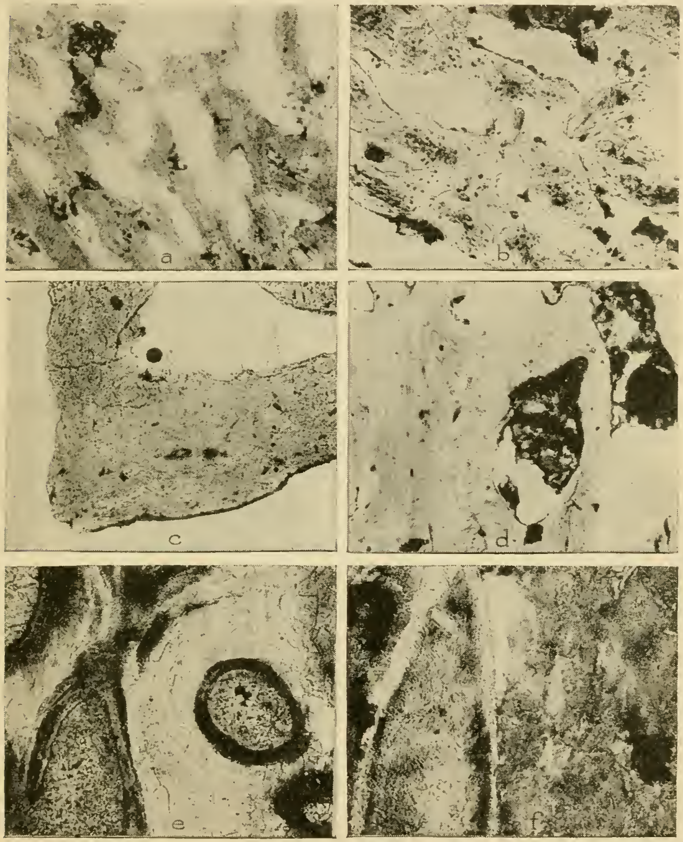

Fig. 16.—Photomicrographs from various portions of fossil lesions. *a*, mosasaur bone showing numerous vascular spaces; *b*, mosasaur bone; *c*, toe bone of Pleistocene wolf; *d*, a recent bison, osteomyelitis; *e*, a Haversian-like arrangement in a fossil reptile bone; *f*, a coprolite showing spicule of bone containing bacteria.

nature of fossil bone was necessary. Such a review has been made and its results will be recorded. Third, one must venture out of his chosen realm of thought and is likely to regard a geode as a tumor; a postfossilization fracture as evidence of caries; a normal muscular eminence as a callus following fracture. However, with care and the advice of friends, experts in their fields, the subject may be pursued with profit.

The subject had its inception in a difficult way. While it was being studied and defined among Paleozoic animals in America, Ruffer, thousands of miles away, was studying and defining it among the ancient Egyptian mummies, the workers being equally unaware of the others. My work has been to fill in between the ancient evidences of disease in the Paleozoic (Fig. 4) and the evidences of pathology among ancient men. Hence a knowledge of the status of disease during the Mesozoic is essential to a proper filling out of the subject.

We need not discuss at this time the origin of disease. It may have been present in the Proterozoic or it may have arisen later. I am inclined to think that our conception of the time of origin of disease will be modified by our definition of the term disease. It is a pity that the Permian is not a portion of the Mesozoic, for Permian pathology is more closely related to the Mesozoic than to the Paleozoic. However, to be orthodox, we shall begin our discussion with the Triassic. The following brief tabulation of Mesozoic pathology will aid in appreciating the degree of progress disease had made at this time.

This array of fifteen pathological results is indeed a startling one. I do not say that this is all the pathology of the Mesozoic, but it is all I have seen or heard described, and serves merely as a basis for future knowledge. This array of diseased members argues for a long, preceding history of pathology of which we are largely ignorant. The necroses and arthritides argue for the presence of Mesozoic pathogenic bacteria of various types which are otherwise unknown, although bacteria have recently been seen in an osteomyelitis from the American Permian.

I. Arthritides
   1. Spondylitis deformans (*Diplodocus*, *Camarasaurus*, *Tyrannosaurus*)
   2. Multiple arthritis (rheumatoid in mosasaur)
   3. Arthritis deformans (with osteoma and periostitis)

II. Tumors
   1. Osteoma (mosasaur) (Fig. 9)
   2. Haemangioma (*Apatosaurus*) (Frontispiece)

III. Necroses
   1. Necrosis with hyperplasia { Jurassic crocodile; *Triceratops* skull; *Camptosaurus* (Fig. 17, p. 79); Mosasaur radius }
   2. Caries in mosasaur

IV. Hyperostoses
   1. Alveolar osteitis (mosasaur of Belgium—Dollo)
   2. Exostoses (scapula of *Triceratops*)
   3. Gigantism (hyperostosis in nothosaur)
   4. Osteoperiostitis (humerus of mosasaur) (Fig. 7)

V. Fractures
   1. Skull in *Mystriosuchus* (Triassic) (Fig. 14)
   2. Oblique fracture in humerus of *Hypacrosaurus* and subperiosteal abscess)
   3. Simple fracture in rib of dinosaur
   4. Fracture (?) of tail, accompanied by osteomyelitis (Fig. 18, p. 81)

It will be more satisfactory to discuss briefly the evidence on which the foregoing classification is made:

I. Arthritides: This is a group term used to define all pathological results found in or around the joint surfaces of the limbs, vertebrae, and skull. The lesions are the result of a great variety of diseases.

1. Spondylitis deformans: This is a type (Fig. 11) of pathology found around the articular surface of the vertebrae. It is the result of inflammation in the vertebral ligaments, caused either by infection or injury. It accompanies Pott's disease (vertebral tuberculosis) and may cause a complete rigidity of the spine. Co-ossified vertebrae are often indications of this form of pathology. The united caudals of *Diplodocus* described by Hatcher and Osborn are clearly examples of this type. Other co-ossified vertebrae in the dinosaurs are due to different causes. Thus the co-ossification in the caudals of *Brontosaurus* mounted in the Carnegie Museum is not spondylitis deformans, but osteomyelitis. Spondylitis deformans has a curiously satisfactory geological history, being known in the Comanchean, Cretaceous, Eocene, Miocene, abundantly in the Pleistocene, and very common in the Recent epoch.

2. Multiple arthritis (rheumatoid): This form of pathology, involving the great toe of a large Kansas mosasaur, is the only fossil example known to me. This is a sort of mosasaurian gout, or rheumatism, which must have caused the old fellow some inconvenience.

3. Arthritis deformans: Only two examples of this form of pathology are known to me, both accompanying other pathological lesions. The articular surfaces are only slightly deformed (Fig. 7).

II. Tumors: These pathological growths, neoplasms (Fig. 9), are not due to a definite infection and arise from pre-existing tissues. Only two examples of tumors are known during the Mesozoic.

1. Osteoma: Seen on the dorsal vertebrae (Fig. 9) of a Kansas Cretaceous mosasaur. Not to be confused

FIG. 17.—The right ilium of *Camptosaurus*, a dinosaur in the United States National Museum, showing a large necrotic sinus. The necrosis had resulted in extensive osseous hyperplasia. The infection doubtless arose from an injury possibly received during the pairing season. The individual doubtless had a huge unsightly sore on the hip for a long time, for the extent of the necrosis and hypertrophy indicate that there was an active infection for a long period of time. In man necrosis and hypertrophy, following infected injuries, go on very rapidly, but we are allowed to assume in the case of the sluggish dinosaurs that the reparative and destructive processes went on more slowly. The injury had completely healed before the death of the animal, as indicated in the well-rounded margins of the sinus.

with a hypophysis, but is a true outgrowth of the vertebra.

2. Hemangioma: This has been previously described and appears to be a true tumor. It occurs between two caudal vertebrae of a Comanchean dinosaur (Frontispiece).

III. Necroses: These are the definite result (Fig. 17) of bacterial or other infection. The various types cannot be distinguished in a fossil condition. There are numerous examples known.

1. Necrosis with hyperplasia is present in the ilium of *Camptosaurus* in the United States National Museum and in a mosasaur radius belonging to the University of Kansas.

2. Caries is not common among fossil vertebrates, although Dollo gives an example of it in the mosasaurs, and Leidy and Hermann have described it in the American mastodon. I have never seen an example of fossil dental caries.

IV. Hyperostoses: These are thickenings of bone, taking the form of outgrowths not classified in the preceding groups.

1. Alveolar osteitis, the result of pyorrhea, I have never seen in Mesozoic fossils, although Dollo has described it in a Cretaceous mosasaur.

2. Exostoses are fairly common and assume a variety of forms.

3. The pathology of gigantism, or extreme osseous hyperplasia, is suggested by Volz and Abel as an explanation of certain hypertrophied nothosaur and fish bones.

4. Osteoperiostitis: This is a diagnosis assigned as the cause of the pathological excrescences seen in a Cretaceous mosasaur from Kansas (Fig. 7).

V. Fractures are of a variety of types, depending on the situation and the degree of pathology involved (Figs. 6 and 14).

1. Skull fracture in the Triassic *Mystriosuchus* (Fig. 14) reported by von Huene. Occurs immediately anterior to the nares.

2. Oblique fracture with subperiosteal abscess seen in the humerus of *Hypacrosaurus* in the American Museum. A common form of pathology today. The

bridge of bone present in the fossil humerus is due to an elevation of the periosteum by an enormous abscess capable of holding several liters of fluid.

3. Simple fracture, commonest type of fracture among fossil animals. An example in the mounted skeleton of *Apatosaurus* in the Field Museum.

FIG. 18.—The mounted skeleton of a huge dinosaur, *Apatosaurus louisae*, in the Carnegie Museum, shows an interesting form of pathology which indicates osteomyelitis, possibly following an injury. The lesion does not have the same character as those of spondylitis deformans seen in caudal vertebrae of *Diplodocus*. The surface of the lesion shown above is pitted with irregular necrotic sinuses, indicating a serious infection such as seldom accompanies spondylitis deformans. It is impossible to be sure that the present case is osteomyelitis without examining the vertebral articular surfaces, but it was due to an infection of some sort. Coalesced caudals are not uncommon in dinosaurs but this differs from any other example of coalescence.

4. Fracture in tail of *Brontosaurus* with osteomyelitis (Fig. 18).

It will be apparent, especially to those interested in other lines of paleontological research, that the foregoing discussion relates entirely to the fossil reptiles; and, indeed, I know no other Mesozoic pathology. The Mesozoic fishes, amphibians, birds, mammals, and hosts of invertebrates have not been drawn on at all, for the reason that I know very little of pathology in these fossils. It is rather strange that no pathology is known among the hosts of Cretaceous fishes. Various types of tumors are said to be common among recent fishes, but I know of no examples among fossil fishes in any age. This shows clearly how meager is our present knowledge of Mesozoic pathology and what great vistas of research are open for future exploration.

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CHAPTER V

DISEASE AND INJURY AMONG FOSSIL MEN AND THE BEGINNINGS OF SURGERY

Syphilis among Ancient Men
Stone Cultures and the Age of the Human Race

The remains of ancient Stone Age man occasionally show evidences of disease and injury. These evidences among the Neolithic and Paleolithic races of Western Europe have been studied by Raymond and Le Baron, and mention of sundry other lesions is to be found in the writings of Keith, Manouvrier, Ruffer, Baudouin, and other students of anthropology. These studies are based on remains of human races found in Western Europe, since no representatives of the Stone Age men, as they are called, have been found in the Western Hemisphere. The remains of these early races are scanty, and many of the skeletal elements are normal. Some few, however, give us an insight, because of their pathological conditions, into the possible cause of their pathology and the necessity of the introduction of surgery to care for these injuries. Trephining, itself a traumatism, was introduced quite early (Fig. 19) among ancient man, as were finger amputation, cauterization, and possibly scarification. These phases of primitive surgery are discussed in chapter vi, and it remains to point out the original need for surgery, the factors underlying its development, as well as the data on which these conclusions are based.

Man's oldest representative, or man's precursor, is identified in the oldest well-authenticated skeletal man-like remains found in 1891 by Dr. E. Dubois, at that time a surgeon in the Dutch Army, stationed in Java. In the

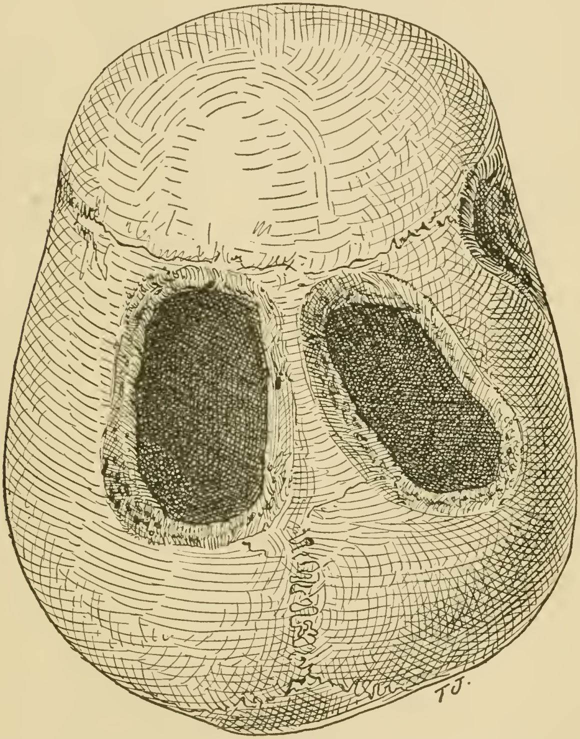

FIG. 19.—Trepanation is the oldest surgical art. Examples of this process are known throughout human history, beginning with Neolithic man, fully 10,000 years ago, and it is still practiced to this day by primitive people in Kabylia, South Sea Islands, and in Peru. Huge defects, exposing wide areas of the cerebral cortex, were often made in the skull. Whether this practice arose in the Paleolithic times is not known but it had attained a high degree of development in the Neolithic era especially in France. It may have been performed for the relief of depressed fractures but there is little evidence to prove what it was for. The skull shown above is from the Neolithic of France and exhibits three large defects due to trepanation (from Keith).

leisure of his station he had undertaken paleontological excavations along the banks of the Solo River, near Trinil, in the central part of the island of Java. He found, quite widely scattered, a calvarium, some teeth, a portion of a jaw, and a left femur entire. These important remains were described by Dubois in a finely illustrated quarto issued at Batavia in 1894. His work was immediately received as one of the greatest contributions to the study of the antiquity of man. Although a very extensive literature has developed concerning the antiquity of man, this discovery still ranks as the most marvelous revelation of man's ancestry so far known. The interest to us in this curious apelike form is that the femur shows marked exostoses indicating the presence of a pathological condition of great severity. This is the oldest evidence of pathology in a humanoid form.

On account of the very great interest attached to such a discovery the pathology has been widely discussed. The great pathologist Virchow, who was also an eminent student of anthropology, called attention to the similarity of the medial exostoses on the femur of the ancient form to those seen in modern femora. He exhibited a number of these which he had selected from the collections of the Berlin Pathological Institute.

The next oldest known form representing man is that designated *Eoanthropus*, meaning the dawn man. Sir Auckland Geddes, after an examination of the Piltdown remains, decided that this ancient Englishman, who lived and died thousands of years ago, had suffered a pathological alteration of the bones of the skull. He based his conclusions on the remarkable thickness, coupled with the characteristic outline of the temporal ridge, which can only find their diagnosis in Acromegaly. He fails, however, to differentiate this condition from Paget's disease[1] which produces a similar pathology. It is possibly due to this factor that the remains were preserved. Thus it is seen that the oldest representatives of man had suffered from disease. Where there is disease or injury even among wild animals, there is always some instinctive, though primitive, means of healing. While from the actual evidences nothing whatever is known of the state of surgery during the most ancient periods of man's development, may we not safely surmise that these primitive apelike humans pondered in a vague way over the means of curing disease and injury, and thus laid a foundation for the development of that knowledge of surgery which we see emerging from the darkness in the late Paleolithic and early Neolithic races, thousands of years later? An instinctive licking of an injury is the forerunner of antiseptic appliances, or the sucking of pus wounds. Quietness and seclusion after fracturing a limb was the instinctive act preceding the use of bark, skin, or hardened clay splints.

The most famous of the skeletal remains representing men of the old Stone Age, when surgery had its first recorded existence, are the portions of a skeleton of an extinct species of man found in a cave in the valley of the Neander River, in the Rhine Province of Prussia, hence the individual is known as the Neanderthal man. The proximal end of the left ulna had evidently been fractured since there is a marked widening of the articular fossa.

[1] Lortet and Gaillard have described the skull of a mummified ape from ancient Egypt, which shows the effects of Paget's disease or osteitis deformans.

The left humerus also shows signs of injury in consequence of which it doubtless remained much weaker than the right bone. Virchow thought that the condition of the bones of this ancient man indicated *rickets*. If so, this would be the oldest evidence of rickets in man,

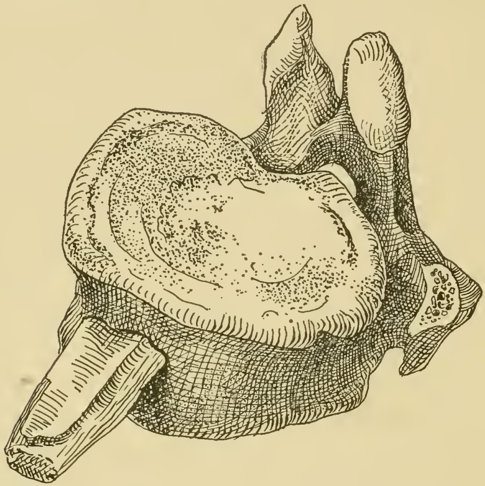

Fig. 20.—Injuries of the war and of the chase furnish a part of the evidence of paleopathology. Rare specimens, such as the one figured above, indicate the nature of the injury which often produced the death of the one afflicted. Arrow-point injuries of vertebrae, skulls, and limb bones are known from a variety of ages and from widely scattered places in the two hemispheres. The present instance, from the Neolithic of Europe, doubtless caused the death of the individual since there is no callus formation or other indication of a long-standing infection such as would naturally ensue following such an injury (after Verneau).

but Schwalbe restudied the question and decided that there was no evidence of malnutrition and his conclusions are widely accepted.

One of the most interesting cases of ancient injury which has come down to us is a specimen of lumbar vertebra of a late Stone Age man, showing an arrow point deeply (Fig. 20) imbedded in the visceral surface.

Older injuries of a similar nature teach us that ancient man was liable to such inflictions incident to war and the chase. During this period, wounds made by blows from stone hatchets, arrow and spear points are fairly common. Many of these injuries, as shown on the remains found in the ancient sepultures, show evidences of long standing and final healing, thus pointing, indistinctly to be sure, to some preventive measures being taken. Le Baron from his study of ancient human skeletons arrived at the conclusions that early man reduced and fixed fractures with great perfection, evidenced by the great numbers of well-healed fractures. Among eighteen cases he examined, only three had healed badly.

Nearly all types of fractures are found among the remains of ancient man. The frequency of spondylitis deformans is striking. Pott's disease (Fig. 21, p. 90) was occasionally observed. Alteration of skulls due to ulcerations; scoliosis; various hyperostoses; caries of bone and teeth; atrophy of the skull; exostoses and osteomata; and many varieties of arthritides indicate to us the variety of afflictions to which early man was subject. It is no wonder that, with this array of pathology to contend with, early man saw the necessity of dealing with them. While many of the earliest recorded evidences of surgery were developed as a phase of religious procedures, there must have been many therapeutic measures known to them which have not been recorded but whose presence we may infer from the pathological evidences of their skeletal remains. Surgery then in its earliest beginnings was derived from three sources: (1) instinctive acts after injury or during the progress of a disease; (2) surgical operations on the body which though developed in connection with religious practices often had therapeutic results; (3) voluntary mutilations, practiced apparently since the earliest dawn of humanity. This was the condition of pathology and

FIG. 21.—Tuberculosis of the spine has a very ancient history, proved by the present case from the Neolithic. The Neolithic skeleton was that of a young man about twenty years of age, and was found in a grave of proved Neolithic age (7000–3000 B.C.) near Heidelberg and regarded by Bartels, who described the skeleton as the oldest case of Pott's disease. The symbol "R" refers to the costal articular facets. The Roman numerals refer to the position of the vertebrae in the thoracic series. The kyphosis is quite evident (after Bartels).

surgery among those manlike creatures of the hills and forests from whom the modern human races have slowly evolved.

SYPHILIS AMONG ANCIENT MEN

In studying the evidences of syphilis among early human races, it is very important to keep in mind the nature of the fossil bones of extinct animals which show hypertrophy, hyperostoses, and carious roughening quite similar to the lesions frequently diagnosed among ancient bones as syphilis. Such diagnoses are of uncertain importance, unless backed by further evidence. Virchow called attention to this similarity in his paper on the history of syphilis. He had previously described and figured carefully the hypertrophied and roughened radius of a cave bear which resembles strongly human bones showing lesions ascribed to syphilis. Virchow applied the term "Höhlengicht," or cave gout, to some of the lesions of the cave bears, referring especially to the spondylitis deformans and other arthritic lesions seen in cave bears of the Pleistocene. It may be safely said that syphilis has not been definitely shown to exist anywhere in fossil or subfossil bones. The earliest accepted date at which syphilis is definitely known is 1495, when the sailors of Columbus carried it to Naples.

The tubercle of Carabelli, described by the noted dentist of Vienna, as the "*Tuberculum anomalus*" occurs on the anterior, lingual surface of the first, second, and frequently the third upper molars. Since aberrant cusps may develop at any one of three places along the lingual margin of the molar, there has often been some confusion in the proper identification of the tubercle of Carabelli. The presence of this cusp is often said to be indicative of congenital syphilis, and Jeanselme relates that treatment for congenital syphilis is often instituted on the basis of the presence of this cusp. The fact that this cusp is more frequently present in children than in adults and in primitive races more frequently than in civilized races, and its widespread occurrence in Neolithic and Paleolithic dentitions calls for its discussion in this place. Gorjanovic-Kramberger says that the tubercle occurs in nearly all of the first and second upper molars of the fossil human skeletons from Krapina, which represent a race of men who lived about 75,000 years ago. He has given an excellent photograph of the tubercle of Carabelli on the molars of fossil man, and for comparison similar cusps on the molars of a native of Java are shown. Batujeff has shown that the presence of this cusp in the primitive races of man and many genera of apes is of wide distribution. I do not doubt that a careful study of the upper molars of fossil primates would reveal the presence of similar cusps.

Since the tubercle of Carabelli has such an ancient history, being demonstrable many, many thousands of years prior to our knowledge of the occurrence of syphilis, it is difficult to see that the two have any significance as a diagnosis of disease. Especially is this a probable solution since Hutchinson's teeth, so long regarded as diagnostic of congenital syphilis, have been recently shown to be due to faulty nutrition. The tubercle of Carabelli may be regarded as the persistence of an ancient character, and while it may be hereditary, it certainly can have nothing to do with syphilis.

STONE CULTURES AND THE AGE OF THE HUMAN RACE

(After Osborn)

Geological Period	Stone Cultures and Cold Periods	Division	Human Types	Animal Types
RECENT Duration 25,000 years	Bronze age Neolithic	Prehistoric Neolithic	Modern races Ancestors of modern man	Recent faunas Reindeer periods
	Azilian-Tardenoisan Magdalenian Solutrean Aurignacian 25,000 years	UPPER PALEOLITHIC	Grenelle Cro-Magnon Grimaldi Neanderthal Neanderthal	
	Mousterian 50,000 years		Neanderthal (Krapina)	Ancient horses, elephants, hippopotami, woolly rhinoceros, hairy mammoth, lions and bears
	Acheulean 75,000 years	PALEOLITHIC		
	Chellean 100,000 years		Piltdown man	
	Pre-Chellean 125,000 years			
	Third glacial period 150,000–200,000 years			
	Second interglacial period 200,000–350,000 years			
	Second glacial period 350,000–400,000 years			
	First interglacial period 425,000–500,000 years		Heidelberg man	Cave bears and their associates
			Man's precursor Pithecanthropus (Trinil)	Saber-toothed cats, ancient horses, elephants, extinct mammals
PLIOCENE Duration 500,000 years	525,000 years from the close of the Pliocene to the opening of the Recent			Extinct mammals

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CHAPTER VI

PRIMITIVE SURGERY

A discussion of the evidences of primitive surgery is essential to a proper rounding out of the subject of paleopathology, because the practices in themselves indicate the presence of disease or injury and also the surgical results, on account of the crudity of the operations, often resulted in an intense form of pathology. Surgical procedures, then, among primitive human races are of interest not only in showing something of the nature of the mind of primitive man but enables us to trace the rise of the surgery of today. We find that many surgical ideas arose in the dawn of human history, many thousands of years ago, and persisted for a long period of time, terminating only with the development of modern surgical ideas on the basis of our modern conceptions of asepsis and all the other remarkable discoveries which have made surgery an important factor in modern life.

Primitive surgery arose in conjunction with the religious practices of shamanism. When the shaman, or medicine man, or priest, amputated a finger, trephined a head, cauterized a scalp, or sucked the pus from an infected wound, he had no intention of counteracting any antagonistic phase of nature, but his belief was to let out the evil spirits, to exorcise a demon, or in some manner to appease an angry god. Gods dwelt in every object of nature, and the mind of primitive man saw only the steps necessary to appease them. Surgery, thus, had its beginnings, and to these simple beginnings the name *surgery* has been applied because the same results are obtained now with what we believe a more rational basis of work.

Shamanism, from which early surgical procedures were evolved, is well known in many parts of the world as a phase in religious evolution. All races of men at an early stage of their development display this form of concept in some manner. Although the term was first applied only to the practices observed among the tribes of Northern Asia, it has been more generally used to express the placation and control by magic or fetishistic rites of spirits or demons which are supposed by primitive man to rule all mankind, and, indeed, the whole realm of nature. The shaman was thus not only a practitioner of sorcery, able to drive off the spirits which bring death, sickness, and misfortune, and to invoke others which confer success and love, but he was a priest, who by communion with the higher powers learns, and afterward teaches to others, the form of practice used in the cult. The term "medicine man" is an awkward compound, invented by the early explorers of North America, which is entirely misleading, since it conveys some conception of therapeutics. If they had any pharmacal knowledge or any idea of healing, it was a secondary matter to that of appeasing the spirit. Primitive man had no idea of what constitutes surgery. The processes performed by them we call surgery now, and they do indicate some knowledge of ligation, stoppages of hemorrhage, sepsis, and the like.

STONE AGE MAN'S CURE FOR HEADACHE

Headaches are bothersome things. People have been annoyed by them for a long time, several thousand years at least, and probably longer. We are all quite willing, when afflicted with a headache, to agree with the people of the old Stone Age that a headache is a demon, and we would be willing to do most anything to get rid of it. The pain, whether due to a blow on the head, indigestion, nervousness, or other cause, certainly reminds one of a demon, and it is readily understood how ancient man should have conceived the idea of releasing this demon which was bothering him. He devised a remedy which certainly was an effective cure for headache, whether the pain was due to eyestrain, brain tumor, skull fracture, or nervousness, although it must be admitted that his cure was worse than the pain (Fig. 22).

Primitive man devised his curative measures as a phase of his religious beliefs, hence the cure adopted for headaches was a religious rite. The operation was performed by a shaman or medicine man in some remote fastness of his region and here the patient remained until completely recovered. This treatment consisted in opening the skull in a variety of ways to relieve the pain, or, as the Stone Age men thought, to let out the demon. Men in the Stone Age phase of their culture, whether in Peru, Mexico, France, Kabylia, or the South Sea Islands, practiced this method of relief and it is said to be still employed in the highlands of Peru and Bolivia and in Northern Africa.

This ancient surgical art, which forms the very beginnings of prehistoric surgery, seems to have been

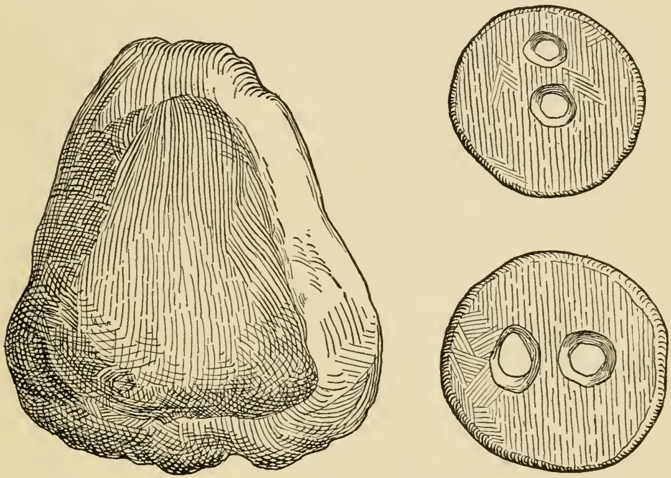

FIG. 22.—Stone Age man's cure for headache was doubtless effective, but in this case the cure was worse than the disease. Trephined skulls of men, women, and children indicate a great prevalence of this method of healing, the patient often returning as many as five times for treatment, until the top of the head was badly riddled with huge holes. The large plaque of bone on the left was doubtless removed from a dead skull, indicating that the ancient medicine man practiced and perfected his skill on the dead. Often these "rondelles" were perforated to be worn as necklaces, as shown on the right.

developed first in the region just north of Paris near the Seine and Oise rivers more than ten thousand years ago. In the dolmens, or burial mounds, have been found the ancient skulls trepanned or opened to release the headache demon. No special class of individuals seems to have been favored since the operation was performed on man, woman, and child, apparently without respect to either age or sex. Its frequency is attested by the great number of skulls exhibiting the surgical openings. In one burial mound in France yielding the bones of 120 individuals more than 40 showed the effects of trepanation.

It is not very pleasant to picture the torture undergone by the ancient sufferer at the hands of the priest who either cut, scraped, or bored the bone of the skull away with a sharp piece of stone. Some relief from pain may have been had by the application of a quid of coca, a plant yielding anesthetic substances which grows in Peru. But the worst thing about headaches is that they recur, so the ancient people not deterred by one failure submitted themselves to the operation again and again. A few ancient skulls reveal five cruel openings, which had all healed. The patient had survived them all.

The equipment of the primitive surgeon was meager. His knowledge of cleanliness was not keen. If he possessed a rough flint knife, a scraper, a few leaves of the coca plant, and a piece of coarse cloth to bind the wound, he was content. A mossy bank out in the woods served him for an operating table.

PREHISTORIC TREPHINING

Trepanning, or trephining, the skull was an operation frequently performed 10,000 years ago in Neolithic times, especially in Western Europe, and in Bohemia. Evidences of its practice in early times are also found in Bolivia, Peru, North America, Mexico, and Central

America, although none of these latter evidences are of Neolithic age. There is no evidence of the operation being performed by either the Hindus or Chinese, nor among the Greeks and Romans. A single doubtful example is known from Egypt. Some trepanned skulls have been discovered in Gaul, belonging to an epoch corresponding to that of Roman civilization.

The contemporary hill tribes of Daghestan, the natives of Tahiti, the Polynesians, and Loyalty Islanders, the Kabyl tribes (but not the Arabs or Negroes in contact with them), Montenegrins, and the Aymara Indians in Bolivia and probably in the highlands of Peru still perform this operation, and thus express their belief in its efficacy. The operation is often performed following a depressed skull fracture received in one of the frequent brawls of the Indians on feast days. Many of the skulls showed evidences of more than one operation and as many as five have been seen. The openings are large and crudely made, and the operation, fatal in a very high percentage of cases, must have been excruciatingly painful(5)

Common and widespread as trephining was in Neolithic times yet very little is known of its purpose or the method of procedure of the prehistoric surgeon. Broca decided that prehistoric surgical trephining was performed for the relief of certain internal maladies. He suggested that it was performed on young epileptic or mad persons to rid them of the "genius," the "demon" causing the dreaded symptoms. They may have performed the operation for the relief of depressed fractures, but as most of the trephined skulls show no signs of accidents, headache was very probably the chief indication for this operation. A religious significance has been attached to the procedure, but there is no recent evidence to support this view.

USE OF THE CAUTERY

The idea of using heat as a means of exorcising the demon of disease appears to have a very ancient history, beginning in the Neolithic. On skulls found in Neolithic dolmens of northern France, Manouvier, a French anthropologist, first investigated the curious lesion, since known as the "sincipital T." This lesion is now known to be due to the cauterization of the scalp, taking the form of a T-shaped cicatrice. The lesion was in the form of an anteroposterior groove or ridge, extending from the anterior curve of the frontal bone, along the sagittal suture, terminating usually near the obelion, where the transverse branch is encountered, but at times extending on down over the occiput to near the foramen magnum.[6] The skulls were all those of females.

A pre-Columbian female skull from Peru also shows an analogous scarification, as if heat had been applied to the scalp, the resulting wound having been badly infected, producing an extensive hypertrophy of the outer table of the skull. The pathological areas form a variant of the Neolithic sincipital T, being in the form of a Latin cross with the longer portion of the upright anterior to the obelion.[7]

By the use of our powers of imagination we see in pre-Columbian times, in a secluded spot in the highlands of Peru, a primitive blanket- or skin-clad shaman holding the head of this demented woman on his knee while he very roughly cuts her scalp with a flint knife, first a long anteroposterior incision, then transversely across the obelion in the form of a Latin cross. Near by on a

FIG. 23.—The pre-Columbian female skull from Amazonas, Peru, showing a variant of the sincipital T (shown at *A*). The cauterization must have been very intense since great osseous ridges have developed along the lines of the incisions. The nature of the bone seen in a cross-section of the right parietal ridge is shown in *B*. The form of the cicatrice suggests a lesion following surgical interference. The skull may be 500 years old, or older. It lay in an ancient cemetery partly exposed to the weather, so its exact age is uncertain. It is however probably pre-Columbian. (Original is in the American Museum of Natural History.)

slow, wood fire is an earthern pot containing the fat of a llama. Close to the operator's hand lies a twisted rope of vegetable fiber. As soon as the incisions are made the surgeon tenses the scalp so as to make the wound gape, then with the wisp of vegetable fiber he applies some of the bubbling oil to the wound. The application of boiling oil to the wound would result in an instant and hearty response, and the patient would have an instant, though possibly temporary, relief from the demon of insanity. The shaman, still holding the patient's head, urging her to control her wild yells of pain, applies to the cauterized wound a quid of coca, which he had been quietly chewing during the operation, and binds it in place with cooling leaves by means of dirty strips of blanket or other cloth. The riotous infection which followed gave rise to the pathology which is present on the skull, but the woman recovered and lived many years after the healing of her surgical wound. There is no indication that she ever had another attack of melancholia. The memory of the boiling oil was too vivid.

SCARIFICATION

The antiquity of the practice of producing scar tissue on various parts of the body can be inferred from its modern prevalence among primitive peoples. The primitive races of Australia, and some of the tribes of Africa, at the time of puberty, or later, have a custom of scarifying the body with long, though not deep, cuts of a flint knife, involving the skin and superficial fascia. The resulting scar tissue was thought to be beautiful and enhanced the attractive qualities of the individual.

Some knowledge of anatomy was expressed in the care that was taken to avoid the larger blood vessels. The incisions, made a few at a time, bled profusely, and no apparent attempt was made to arrest the flow of blood. To secure a beautiful adornment of the body often consumed several weeks or months. It is remarkable that there are so few cases of sepsis involved either in tatooing or other forms of scarification, and the absence of keloids, to which negroes are especially prone, is an interesting commentary to the oft-recorded observation of the immense resistance possessed by primitive races of man and wild animals.

AMPUTATION OF FINGERS AND OTHER MUTILATIONS

Silhouettes of hands in red and black are depicted on the walls of a cave at Gargas, Spain, indicating that in the Aurignacian age (late Paleolithic, possibly 25,000 years ago) primitive man had already begun to mutilate himself. He spared a finger to appease a god, until often he had none left. The impressions of amputated hands on the walls of the late Paleolithic caves are present in great numbers, over 200 being recorded. They indicate a truly shocking prevalence of finger amputations among the early human races. The custom still persists in modern primitive human tribes.

Similar imprints showing amputated fingers are found on the walls of caves in California, Arizona, Peru, Africa, and Australia, in recent times, and an imprint, known as the "red hand," has been observed in Egypt, Palestine, Arabia, Babylonia, India, Phoenicia, and Mexico. The purpose of the amputation was as various as the countries in which it was employed. It was a symbol of mourning in the Nicobar Islands. It was a sacrifice in India, demanded at the death of a ruler. It was a part of the initiation ceremony among certain Indians of North America; to appease an angry god; as a distinguishing mark of caste; as a preparation for marriage; and for other reasons more obscure.

The operation was often confined to the little finger, and was performed by a flint knife, the incision being made at the joint and the first amputation involving only the terminal phalange. Hemorrhage was stopped by a bandage, by applying fats, and by a heated stone. Rare cases have been observed in which an individual, usually a woman, had sacrificed the last two joints of all her fingers. (9)

PRIMITIVE SURGERY IN THE LAND OF THE INCAS

The most highly developed surgical art in the highlands of Peru, in the time of the Inca princes, was that of trephining. No other area in the world has produced so many trephined skulls, some of them having undergone the operation five times. The methods of procedure seem to have not been uniform, but were of three or more types. The surgical technique employed in this operation by the ancient Indians is suggested by the steps followed in recent times observed in the highlands of Bolivia. This modern practice is doubtless a direct descendant of ancient times.

The operation in Bolivia is performed by the shaman with a well-sharpened pocketknife, a piece of glass, or a sharp-edged stone, the process being one of cutting and scraping. The operation is often performed following

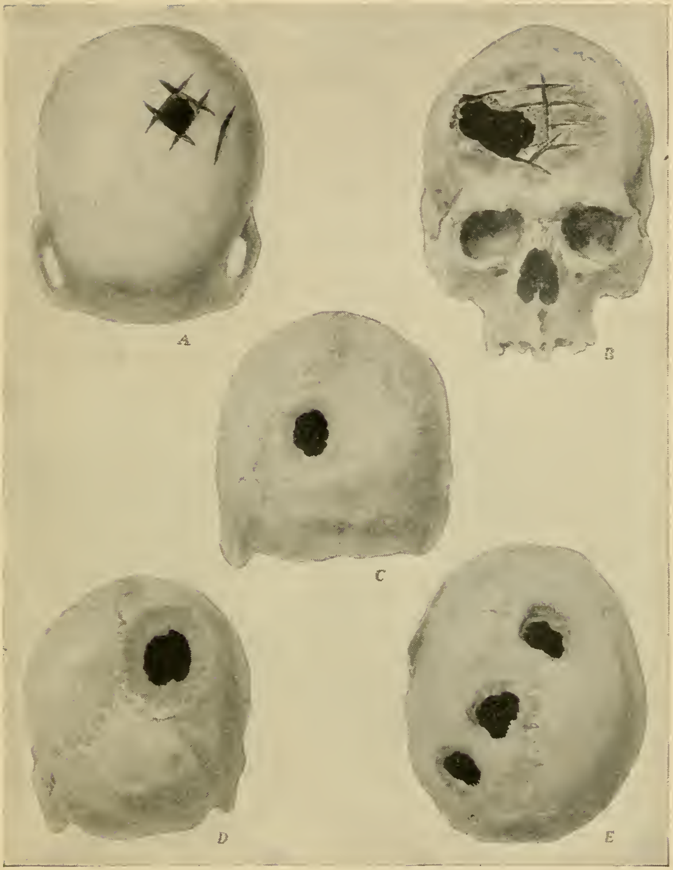

FIG. 24.—Ancient Peruvian trephined skulls, showing different types of openings: *A*, Skull opened by a saw or notched knife. An attempt was made at a second opening to the right of the completed opening. *B*, Skull showing very crude opening in the right frontal, with a large plaque of bone removed, after several abortive attempts. The darkened areas around the opening are blood stains. It is doubtful if this individual survived the operation. *C*, Skull with small, rounded trephine opening in the left occipital region. The patient survived the operation for many years since the margins of the opening are completely rounded. *D*, Skull with large rounded trephine opening in the right parietal. The margins slope greatly, indicating some scraping process. *E*, Skull with three moderate trephine openings on the vertex (after Muniz and McGee, "Primitive Trephining in Peru," *Smithsonian Report.* Washington, 1894–95).

a depressed fracture of the skull received in one of the frequent brawls of the Indians who are continually drunk on feast days. The openings in the skull are large and rudely made, and the operation, fatal in a high percentage of cases, must have been excruciatingly painful. The plaques of bone, after being taken out, were not replaced, but a mass of grass or any dirty cloth in reach was inserted under the scalp.

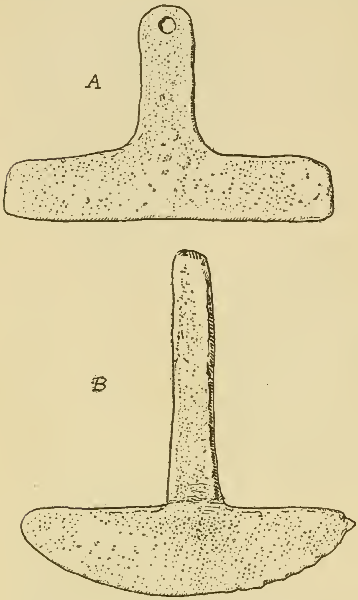

FIG. 25.—Primitive surgical instruments of metal (copper or bronze), doubtless used by prehistoric Peruvian surgeons in performing the operations of trephining, amputation, and incisions. The instruments are well adapted to the various procedures involved: cutting, sawing, scraping, and boring. *A*, *B*, bronze or copper instruments to which a haft of wood was fixed and tied with thongs.

The use of the cautery in producing lesions of the sincipital T has already been discussed. Only one example is known from Peru.

Judging from the evidences of their pottery, the ancient Peruvians also performed amputations, and removed infected areas, cut out parasites, and did other things now included under surgery.

SURGERY AMONG THE PRE-COLUMBIAN INDIANS OF NORTH AMERICA

The evidences of ancient surgical practices in North America are very meager; it was in a rude state of advancement. So far as we know trephining was not practiced nor was cauterization used. The Indians were still in the Stone Age of culture, and they really knew less about surgical procedures than many other races of similar advancement. More recent Indians seem to have known how to remove small tumors, and were versed in the art of the ligature, using in late centuries horse-hair for this purpose. Blood-letting, which they doubtless acquired from the whites, was extensively employed, irrespective of the disease. More ancient Indians seem to have been skilful in the use of splints for fractures, and they developed a variety of forms of protection for the injured limb. A set of splints made of bark, curved to fit the limb or else padded with wet clay, which on hardening made a very good support, was doubtless employed over a long period of time. Another device was to wrap the injured limb in wet rawhide, which on hardening made a firm support. They also devised rude corsets of bark to be tightened with laces for support of spinal or abdominal difficulties. They strapped the mammae in case of abscesses, and bandaged the thorax in cases of pulmonary inflammations. Amputation may have been extensively employed, hemorrhage being stopped by hot stones.

SURGERY IN ANCIENT EGYPT

Since surgery had so great a vogue among Neolithic peoples, 25,000 years ago, it is only natural that we should find evidences of it in the place where civilization had its origin, which was in and around the region bordering on the eastern and southern coast of the Mediterranean Sea. The Egyptians played an important part in this early civilization. Present evidences indicate that Egypt has been peopled for 12,000 years at least, and doubtless longer, but we do not know when the first nomadic tribes wandered into the valley of the Nile.

Surgical procedures were developed in Egypt after the period of the First Dynasty, and are first indicated in the Fifth Dynasty, 2750–2625 B.C. On the walls of a tomb of the Twelfth Dynasty, 2000–1788 B.C., the period of the ancient empire, there are depicted several figures of a primitive surgeon in the act of circumcising a boy with a sharp-edged flint knife. The Egyptians early learned to work flint, and predynastic knives, beautifully designed and executed, with elaborately carved gold and ivory handles, are well known. These are doubtless the first surgical instruments, but later, after the discovery of the copper ore, malachite, in the Sinai Peninsula, bronze replaced flint, ivory, and bone.

It is often stated that the ancient Egyptians had a highly developed practice of dentistry, but recent active investigations have largely disproved this statement. A mandible from the old empire (1500 B.C.) indicates that a primitive Egyptian surgeon attempted to drain an alveolar abscess in the right mandibular ramus. Two openings leading directly into the sinus seem to have been made by a sharp-pointed tool to allow drainage. It is well known from the studies of Ruffer that the pharaohs and their subjects suffered tortures from toothache, indicated by the prevalence of dental caries, alveolar abscesses, and pyorrhea. It seems unlikely with all this evidence of a prevalent pathology before us that the Egyptians had any conception of dentistry.

They did, however, know how to apply splints (Fig. 26) to fractures. A set of splints used on a compound fracture of the femur has been found preserved

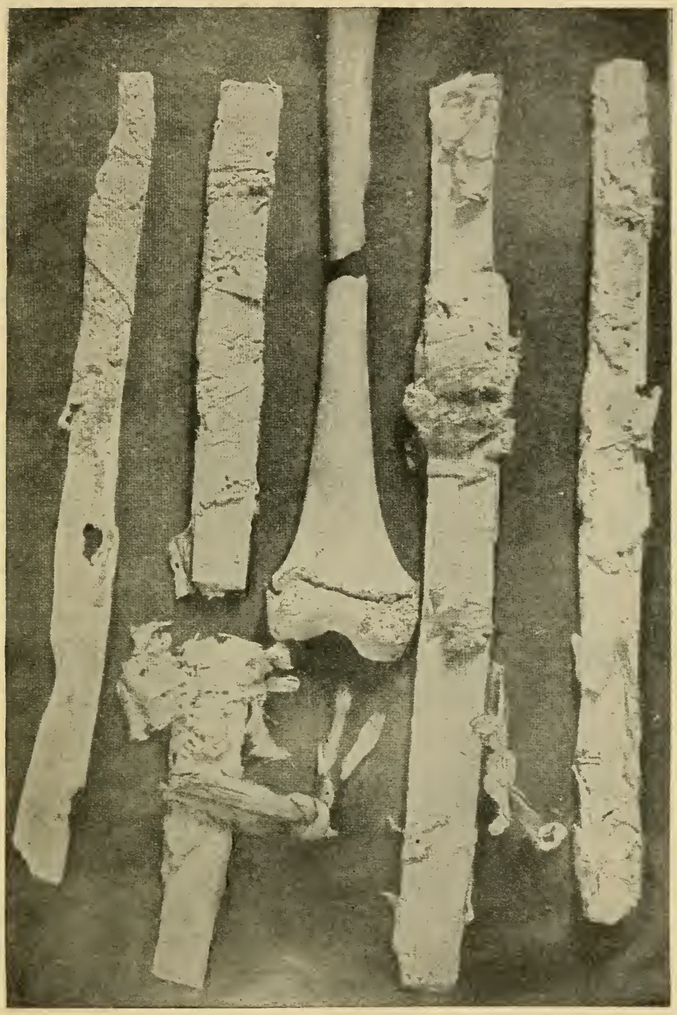

FIG. 26.—Fracture of the limb of an ancient Egyptian set with splints, with blood-stained vegetable fiber for absorption of blood (after G. Elliot Smith).

on the limb of a girl fourteen years old, in the rock tomb at Naga-ed-der, about 100 miles north of Luxor, dating from the Fifth Dynasty (2750–2625 B.C.). The appliance consists of four splints, which formed a sleeve or tube around the entire limb. It was not especially successful since it did not prevent shortening of the limb or hold the fractured ends of the bones in place.

Another set of splints was applied to the forearm in a case of compound fracture of both bones of the left antebrachium. There was a pad of fiber, evidently from the date palm, adherent to the fragment of the ulna, and its blood-stained condition indicates its use as a means of absorption. The splints consist of three pieces of rough bark, arranged in the form of a tube completely around the forearm, strengthened by a bundle of coarse grass.

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CHAPTER VII

PATHOLOGY OF PRIMITIVE HUMAN RACES

Diseases of the Ancient Egyptians
An Eruption Resembling Smallpox
Early Evidences of Schistosomiasis
Hydrocephalus in Early Egypt
A Psoas Abscess
A Pelvic Osteosarcoma
Osseous Lesions in Ancient Egyptians
Symmetric Osteoporosis of the Skull
Rickets in Ancient Egypt
Diseases of the Ancient Peruvians
Pathology of the Pre-Columbian Indians of North America

The study of paleopathology includes properly only the early phases of each race, but it is impossible to draw a line which shall separate the prehistoric from the historic. The discussion of pathology in this chapter will deal only with evidences of ancient pathology, without much respect to the existence of written records, such records dealing always with other aspects of human life.

There are only three primitive peoples of whose pathology we know a great deal, namely, the ancient Egyptians, the Peruvians, and the North American Indians. Our knowledge of the pathology of other races is extremely fragmentary and unsatisfactory. For our knowledge of the paleopathology of Egypt we are indebted to the researches of Fouquet, Ruffer, Elliot Smith, Wood Jones, Lortet, and Gaillard. Hrdlicka has studied the pathology of the ancient Peruvians, to which Eaton has added considerable data. I have described an interesting pre-Columbian skull lesion from ancient Peru. Hrdlicka has likewise produced most of the data for our knowledge of the pathology of the North American Indians of pre-Columbian times. To this I have been enabled to add a great deal by the study of an extensive collection of skeletons loaned by the American Museum.

The following discussions are arranged in the order of the antiquity of the evidence, beginning with the Egyptians, followed by the Peruvians. The North American races are the most recent. It is not thought necessary to introduce figures of Egyptian pathology since this has been adequately done by others. (See bibliography at close of chapter i.)

DISEASES OF THE ANCIENT EGYPTIANS

It was in Egypt that the foundations for the study of paleopathology were laid. Fouquet initiated the subject so successfully followed by Marc Armand Ruffer, G. Elliot Smith, F. Wood Jones, Derry, and others. The pathological conditions which are encountered among the ancient Egyptians, covering a range of several thousand years, are many. Pott's disease, pneumonia, smallpox (variola?), deforming arthritides of many kinds, renal abscesses, arteriosclerosis (atheroma), many types of fractures, necroses, tumors, cirrhosis of the liver, caries, alveolar osteitis, and many other interesting lesions may be discerned.

Syphilis has been reported by De Morgan among the ancient Egyptians, although the evidences, as indicated by Fouquet, are uncertain. Lortet and Gaillard, in their study of the ancient fauna of Egypt, indicated by the mummified remains of the sacred animals preserved by the ancient Egyptians, such as birds, fish, lizards, crocodiles, antelope, bulls, dogs, cats, and other forms of vertebrates, have reported lesions of syphilis on the skull of a young woman. The lesions take the form of irregular erosions in the outer table of the frontals and in the anterior portion of the parietals. They recall those described by Eaton in a child's skull from ancient Peru.

As an evidence of the community of interest between history and medicine may be mentioned the pathological anatomy of the aorta of King Merneptah, the reputed pharaoh of the Hebrew Exodus. The mummy was found at Thebes, in the tomb of Amenhotep II, who reigned in Egypt from 1448–1420 B.C., and was unwrapped by Elliot Smith, who sent the aorta to the Royal College of Physicians of London. The finding of Merneptah's mummy at Thebes of course discomfited the adherents of the theory that, as the pharaoh of the Hebrew Exodus, he must have been drowned in the Red Sea.

Shattuck undertook a microscopic study of the aorta and demonstrated sections before the Royal Society of Medicine in London.

"The sections showed the picture of typical senile calcification of the aorta, the bony parallel, elastic lamellae being perfectly preserved, and the interlamellar material thickly strewn with calcium phosphate."

That Merneptah, who reigned in Egypt from 1225–1215 B.C., thirteenth son and the successor of Rameses II (1292–1225 B.C.), was a man of great age is shown by his baldness, by the whiteness of the little hair left, by the complete ossification of the thyroid cartilage and of the first rib, not its sheath alone, and by the calcareous patches in the aorta. A single tooth, the upper right median incisor, was visible. Although the body was reduced to little more than skin and bones, the redundancy of the skin of the abdomen, thighs, and cheeks indicate that Merneptah was a somewhat corpulent old man.

These interesting observations upon the atheromatous patches in the aorta of the elderly pharaoh were followed by two studies by Ruffer on various arterial lesions found in Egyptian mummies. The earlier and more complete study deals with arteries taken from mummies of the Eighteenth to the Twenty-seventh dynasties (1580–527 B.C.), and from the time of the Persian conquest (525 B.C.). Ruffer also dissected mummies from later periods so that his studies ranged over material representing a period of nearly two thousand years.

The arteriosclerosis of the ancient Egyptians followed exactly the same course as the disease follows today. The small atheromatous patches and the histological anatomy of the vessels are identical with those of today. The earliest sign of the disease now, as then, is in, or close below, the fenestrated membrane. The ancient disease, as well as the modern, was characterized by a marked degeneration of the muscular coat and of the endothelium. The small atheromatous patches subsequently fuse and form large patches of degenerated tissue, which may reach the surface and open out into the lumen of the tube.

The etiology of this disease three thousand years ago is as obscure as it is in modern people. The common causes, such as syphilis, tobacco, alcohol, can almost certainly be eliminated from the life of the ancient Egyptians. The diet and daily life of the ancient Egyptian people was not such as to bring on this disease, and all that can be said is that it was widespread in young and old, and that three thousand years ago the disease represented the same anatomical characters as it does today.

AN ERUPTION RESEMBLING SMALLPOX

In view of Hirsch's suggestion that the Egyptian regions are probably one of the endemic foci of infection of smallpox, Ruffer's discovery of a case of variola, or something very like smallpox, in a mummy of the Twentieth Dynasty (1200–1100 B.C.), is of extreme interest. The body from which the skin was taken was that of a tall man of middle age. This body was the seat of a peculiar vesicular or bulbous eruption, which in form and general distribution bore a striking resemblance to smallpox. The piece described and figured was taken from the adductor surface of the right thigh. The eruption was a closely set vesicular one.

Microscopic examination of the tissue shows the wavy fibrillae and bundles, but no nuclear staining is discernible. Bacteria are present in great numbers. They seem to be the organisms which produced the infection, but the number of bacteria was doubtless greatly magnified after death.

It would not be at all surprising to find smallpox in Egypt at this time since it has been described as occurring in India and in China as far back as 2000 B.C. Although prior to Ruffer's paper there was no definite information on the existence, in early centuries, of this disease on the African continent.

EARLY EVIDENCES OF SCHISTOSOMIASIS

One of the most interesting discoveries made by Ruffer was the recognition of the calcified eggs of *Bilharzia* (*Schistosoma*) *haematobia* in the kidneys of two mummies of the Twentieth Dynasty (1250–1000 B.C.). At the present time there is perhaps no disease more important to Egyptians than that caused by the Schistosomids. So far there is little evidence to show how long it has existed in the country, although medical papyri contain prescriptions against hematuria. The lesions are usually seen in the bladder and rectum, but these two organs are seldom preserved in the mummies, but in the kidneys of two out of six examined Ruffer was able to demonstrate microscopically a large number of calcified eggs of *Bilharzia haematobia*, situated, for the most part, among the straight tubules. Although calcified the eggs are readily recognizable and cannot be mistaken for anything else, proving that renal diseases were not infrequent among Egyptians 3,000 years ago.

Malaria is suggested by the discovery of hypertrophied spleens in ancient Egyptians.

HYDROCEPHALUS IN EARLY EGYPT

The case of hydrocephalus in an Egyptian of the Roman period, described by Douglas E. Derry, is one of the oldest examples of this deformity. The skull, nearly complete, the pelvis, and certain limb bones are carefully described and should be noted in connection with the diseases of the ancient Egyptians. The skeletal parts described belong to a man of about thirty years of age. The teeth were considerably worn, and the individual may have been older than indicated. The stature was estimated to be 1.506 meters in height. The individual was the victim of some disease of the brain, probably hydrocephalus, which not only caused the growth of the skull to remarkable proportions but was also responsible for the partial paralysis of the left side, which has left its mark in a very definite manner upon the skeleton of the parts concerned.

A PSOAS ABSCESS—TUBERCULOSIS—POTT'S DISEASE

The mummy exhibiting the psoas abscess, associated with Pott's disease, or tuberculosis of the vertebral column, was a priest of Ammon of the Twenty-first Dynasty (1000 B.C.), found in 1891 by M. Grébaut in the region of the great Theban city. In 1904 the body, with others, was transferred by order of Director Maspero to the medical school at Cairo, where it attracted the attention of Ruffer and Smith, who have carefully described it, arriving at the conclusion that it is a definite example of tuberculosis, the first one met with in ancient Egypt. The body was that of a young, adult man showing in the lumbar region a very unusual disturbance. The lower thoracic and upper lumbar vertebrae are kinked and necrosed, and on the right side there is a large swelling in the psoas muscle, extending into the iliac fossa.

Microscopic examination of the left psoas shows the presence of unmodified muscle fibers, while on the right side there are indications of great disturbance, with numerous calcified leucocytes, imbedded with the muscle fibers, together with a lot of trash introduced into the body in the embalming process. The right psoas muscle must have been in a semifluid state, as is shown by the imbedding of a large amount of material into the fibers of the muscle, indicating a psoas abcess on the point of rupture.

Tuberculosis has been suggested as the cause of ancient lesions in Egyptian human and animal mummies by Poncet, Fouquet, De Morgan, and others, but Ruffer and Smith are of the opinion that no true case has been established by them, the majority of their lesions being clearly those of spondylitis deformans.

A PELVIC OSTEOSARCOMA

The bone in which the tumor was found comes from the catacombs of Kom el Shougafa, in Alexandria, and dates most probably from the middle of the third century after Christ. Owing to the fact that the tombs had been previously rifled and the skeletons were in a great disarray, no other bones of the skeleton could be identified.

The tumor occupies the right pelvic bone, affecting particularly the ischium and lower part of the ilium, the pubis being apparently normal. The ilium is greatly thickened throughout and the body of the ischium enormously dilated, the enlargement encroaching upon the obturator foramen. The tumor started, doubtless in the cancellous tissue of the pelvis and its growth has caused a very marked expansion of the bone, deformation of the obturator foramen, and encroachment upon the acetabulum. There are numerous grooves on the surface suggesting that the tumor was highly vascular. The exact nature of the lesion must remain uncertain, but owing to the fact that the swelling is deeply seated, partly solid and partly cystic, and had evidently been growing fast, Ruffer is of the opinion that this tumor was probably an osteosarcoma, of which the bony substance has resisted the effects of time, while its soft parts have disappeared. This is the only known ancient example of an osteosarcoma, unless some of the tumors seen in the ancient dinosaurs are of that nature.

OSSEOUS LESIONS IN EARLY EGYPTIANS

There is a great wealth of material on the osseous pathology of the ancient Egyptians to be gained from the memoirs of Ruffer and Rietti, Derry, Smith and Jones, and other minor sources of information. A great store of specimens was secured in 1907 and later years when the Egyptian government decided to make an archaeological survey of that part of Nubia which would be flooded more or less permanently when the Assuan dam was raised. Students of medical history were extremely fortunate in this survey for there has been a continuous exportation of Egyptian mummies since the beginning of the Middle Ages, more than one thousand years, material which was thus largely lost for examination. Many of the lesions described by Ruffer have been placed in the museum of the medical school at Cairo.

Spondylitis deformans was extremely common among the early Egyptians, often of a very severe nature,. since one vertebral column, described by Ruffer and Rietti, belonging to a man whose name was Nefêrmaat, belonging to the Third Dynasty (2980–2900 B.C.), from the fourth cervical vertebra to the coccyx, and possibly through its whole length, had been converted by disease into one rigid block, by the formation of new bone in the anterior spinous ligament (Ligamentum longitudinale anterior). Distinct bulging of this osseous bridge, opposite each space for intervertebral disk, allows an examination of the articular surfaces of the vertebrae which are perfectly smooth. The Ligamentum longitudinale posterior was likewise completely ossified although there was no narrowing of the spinal canal.

A less severe case of spondylitis deformans is described in the vertebral column of a woman of the Twelfth Dynasty (2000–1788 B.C.), where the disease is localized in the anterior portion of the ninth and tenth thoracic vertebrae.

The disease seems to have had a continuous history in ancient Egypt from very early times. Ruffer and Rietti describe examples of this condition in bodies from the tombs of the soldiers of Alexander the Great and Ptolemy I at Chatby (about 300 B.C.). The early stages of the disease usually show themselves in the dorsal and lumbar regions on the anterior borders of the vertebral bodies on either side close to the middle line. They are characterized by the formation of a small lip which meets a similar prolongation projecting from the adjacent vertebra. Sometimes the new bone spreads as a thick ridge all around the anterior border of the vertebral body and forms powerful masses which may extend over the sides, meeting with similar ridges, forming finally a continuous mass of bone. The disease seldom extends to the posterior spinal ligament, and even should the latter become completely ossified, the new bone never intrudes on the spinal canal. The lesions never extend into the substance of the bone but are entirely superficial.

The hands of one mummy of the time of the Persian Occupation (about 525 B.C.) showed enlargements of the heads of the first phalanges which may be regarded as Bouchard's nodosities, a malformation which Bouchard has shown to be caused by chronic dilatation of the stomach.

Fractures, with or without callus, are quite common, being described in a left first rib, tibia, and fibula, and a very badly healed leg bone fracture. Smith and Jones have described a number of other fractures and have figured them in great detail.

They figure also an interesting skull of an ancient Egyptian, showing an erosion of the floor of the brain case due to a carotid aneurism.

Caries and alveolar osteitis are frequently met with, and Ruffer has described a number of these cases often associated with necrosis of the surrounding bone, as well as by rarefying periodontitis. He made a special study of these diseases in the skeletons found at Merawi, representing people of the Twenty-fifth and Twenty-sixth dynasties (712–550 B.C.), and at Faras of the Meroïtic age (100 B.C.–300 A.D.). His study is devoted especially to the teeth in adults. There were lesions of the teeth (caries, periodontal disease, alveolar osteitis) in all but two of a series of thirty-six skulls. The lesions were present in the following order of frequency: (1) impaction, (2) attrition, (3) caries, (4) abscesses and fistulae, (5) periodontitis and pyorrhea alveolaris. Besides the very bad dentition there were many fractures. Wormian bones were occasionally observed. Two bones showed deformities due to rickets, and a series of vertebrae gathered from many places showed a continuous history for spondylitis deformans from 4000 B.C.–300 A.D. Ruffer concludes from these studies that the people usually did not survive the age of fifty and life for most of them must have been pretty miserable. There are no evidences that dentistry was ever practiced. Pyorrhea alveolaris especially seems to be as old as the human race, since Ruffer observed evidences of it in skulls of Greeks, Romans, Peruvians, Mexicans, Merovingians, and Germans.

Thoma, 1916, has studied the evidences of dental diseases in 250 ancient Egyptian skeletons (2000 B.C.) preserved in the Peabody Museum at Harvard University. His results agree with Ruffer's.

SYMMETRIC OSTEOPOROSIS OF THE SKULL

A nutritional disturbance, evidently having its inception in infancy or early childhood, was doubtless the cause of the development of patches of porous bone developed in the skulls of certain ancient Egyptians. Thus Adachi has described and figured a skull of a young Egyptian from an ancient cemetery of Siut which exhibits on the posterior half of each parietal, removed from both the sagittal and lambdoid sutures by about 2 centimeters, an elongated, oval area of rounded openings of various dimensions which find their way into the diploë but never into the cranial cavity (Fig. 27).

A similar condition is described in a recent Dyak skull of middle age, in which the porosities are larger and more developed on the left side. Another example of this condition is given by Hrdlicka from ancient Peru.

This curious appearance is generally known as *Cribra cranii* and is usually associated with the *Cribra orbitalia*, discussed below. Hrdlicka first suggested a pathological

FIG. 27.—Healed lesions of symmetric osteoporosis, a disease of childhood, resulting in absorption of the skull bones in unilateral areas, frequently seen in the parietals. The condition is often much more virulent than shown in this ancient Egyptian skull (after Adachi).

significance for these appearances, Adachi having been uncertain as to its cause, though suggesting pressure atrophy in artificially deformed skulls as possible cause.

Cribra orbitalis is a similar condition of the roof of the orbit, and as in *Cribra cranii* the porosities never penetrate the neural cavity but do communicate with the paranasal sinuses. Rudolf Martin has tabulated its occurrence among primitive peoples as follows: Sokotrans 47.6 per cent, Negroes of the East Sudan 35 per cent, Malays 22.5 per cent, Ainos 16.8 per cent, Chinese 13.4

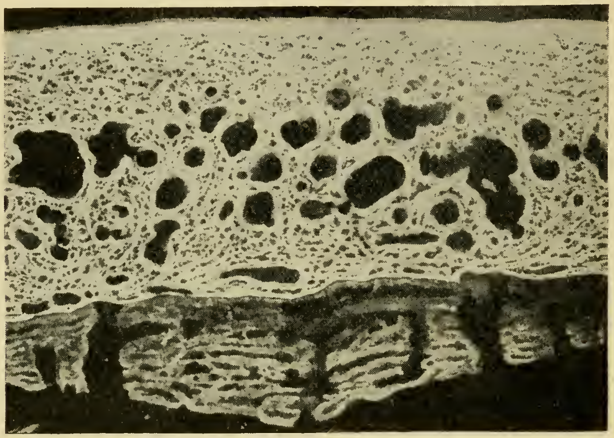

Fig. 28.—*Cribra cranii interna* (after Koganei)

per cent, Mongolians, 8 per cent, Japanese, 11 per cent, in children 27 per cent, in ancient Peruvians 8.9 per cent, in ancient Egyptians 7.1 per cent, and in various European races 3.1–4.7 per cent. Hrdlicka records the recovery of two infant skulls with a coral-like osteoporotic development in the roof of each orbit from a Twelfth-Dynasty cemetery in Egypt, and Welcker has reported other examples. The osteoporosis appears to be absent in Eskimo skulls and in most white races. Carl Toldt found only eleven examples in an examination of 10,000 European skulls, although Ahrens elsewhere reported 17 per cent occurrence among 470 German skulls examined. Oetteking found thirteen cases of *Cribra orbitalia* in an examination of 182 ancient Egyptian skulls.

These interesting pathological conditions, known as *Cribra cranii* (*parietalia*) and *Cribra orbitalia*, are not to be confused with the activities of beetles which produce porosities in ancient skulls, but of such a different character that they are not at all similar.

RICKETS IN ANCIENT EGYPT

Definite evidences of the occurrence of rickets have not yet been found in the human bodies examined from the ancient graves of Egypt, although Poncet, in the memoir by Lortet and Gaillard on the mummified fauna of ancient Egypt, has described rickets in the skeleton of an ape. F. Wood Jones remarks in this connection:

> Some diseases—notably rickets and syphilis—if at all common must inevitably have left traces of their presence on the bony structure of the body, and that such traces have not been found in the large series of bodies examined at Biga and Hesa cemeteries, and by Dr. Elliot Smith in other cemeteries in Egypt, is strong presumptive evidence that the diseases did not occur. The infant mortality was apparently a high one, and great numbers of young people, of all ages up to puberty, are found in all the cemeteries, and yet not one of the cardinal signs of the bony manifestations of rickets has been seen in any case.

The occurrence of this disease among modern apes has been discussed by Bland-Sutton and by Frassetto. Poncet's observations on rachitis in the mummified apes of ancient Egypt is thus an addition to our previous knowledge. The evidence is to be found in a set of limb bones markedly curved which indicate the occurrence of rickets.

Among fossil animals older than the ancient fauna of Egypt the disease has been suggested by P. C. Schmerling in the limb bones of a Pleistocene bear from the caves of Belgium, but his evidence is not conclusive.

Among living animals Frassetto has cited the literature in which the occurrence of the disease has been noted in the pig, horse, dog, cat, cow, sheep, and goat, domestic birds, the turtle, and the primates cited above. Rickets thus seems to have a fairly wide occurrence among recent vertebrates.

DISEASES OF THE ANCIENT PERUVIANS

Pathological evidences of disease in South America are largely confined to the area of the highlands of Peru, chiefly that portion inhabited by the subjects of the Inca princes. Here the evidences are of three kinds: indications of disease on the skeletal remains, such as trephined skulls and pathological bones; representations of disease on pottery; and recorded history.

The high degree of development of the primitive surgical art indicated in the numerous trephined skulls found in the ancient Peruvian burials has been discussed, and figures given, in chapter vi, as has likewise the evidence suggesting the use of the actual cautery by the primitive skin-clad surgeon. No area of similar extent in the world has furnished such numerous evidences of trepanation, which was executed in a variety of methods. The subject has received wide attention, and it seems probable that these primitive races really understood some of the fundamental principles of surgery, practicing on the dead, and even learning to replace plaques of bone, removed for disease or injury, by similar objects of shell, gourd, or metal.

The difficulty of assigning definite periods of time to any Peruvian Indian burial will be obvious to anyone who considers the matter at all seriously. Consequently we cannot be sure that the evidences considered here are of true pre-Columbian age but we may safely say that they are relatively ancient. Of course nothing human in the Western Hemisphere is really ancient compared to the European and Egyptian evidences. Pre-Columbian Peruvian skeletons often bear evidences of disease, and these indications have been studied especially by Hrdlicka and Eaton, as well as a number of modern Peruvian writers, the most active being Dr. Edmundo Escomel, of Arequipa. Unlike the Egyptians the ancient Peruvians do not present marked evidences of skeletal pathology. Spondylitis deformans, from which thousands of the ancient inhabitants of the Nile suffered, and many were totally disabled, is not apparent in ancient Peru in any measure, although there are indications of it in the incipient lipping of vertebrae. Osteophytes on parts of the skeleton indicate the existence of various local disturbances. A general osteomalacia is indicated by one skeleton, but this nutritional disease seems not to have been common. Syphilis of the bones has been reported but the evidence is so uncertain as to be largely worthless. This disease is so readily confused with another disease, *uta*, commonly prevalent in Peru in ancient times and now, that it is not always possible to distinguish the two. Tuberculosis seems to be

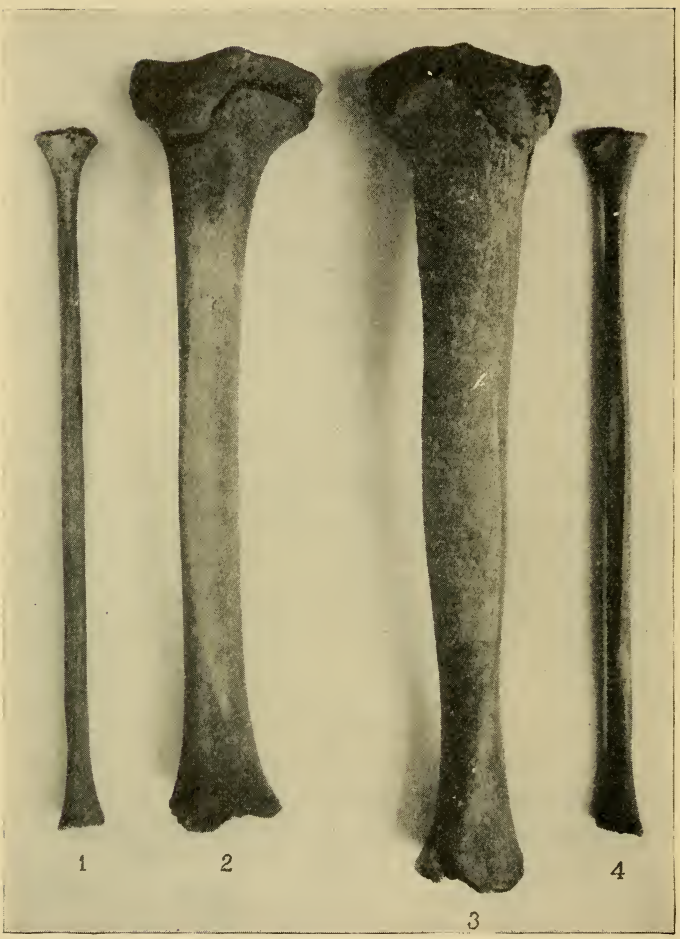

Fig. 29.—Diseased limb bone from ancient Peruvian graves of Machu Picchu, showing hypertrophy and necrosis supposed by some to be indicative of syphilis but the results may as well be ascribed to other infections. Diseased bones, tibia and fibula, on the right, compared with normal bones, on the left (after Eaton).

indicated in certain pathological femora, but no definite evidences of Pott's disease, so common in Egypt and among the North American Indians, are known in Peru. Pulmonary tuberculosis might be determined in the mummified remains, if present, but no one has paralleled

FIG. 30.—A cranial osteoma seen in a Peruvian skull

on Peruvian material the splendid researches of Ruffer on *Histological Studies of Egyptian Mummies.* Dental caries seems not to have been common, and other dental infections were not burdensome. A curious disorder of infancy, possibly a nutritional disorder, known as osteoporosis, chiefly evident (Fig. 27) on the skull, has been discussed under the diseases of Egypt. Osteoporosis has a world-wide distribution, though its exact significance is unknown. Other pathological indications are merely those of a local nature. A single, as yet undescribed, tumor of the skull is in the Yale University collections. It is a large, honeycomb-like affair, so far as I know the only tumor of its kind known on the remains of ancient man.

FIG. 31.—Ancient, pre-Columbian, water jars showing around the mouth and nose the eroded areas due to *uta*, a phase of Leishmaniosis still common in the Andean Highlands. Often the lips and nose are indicated in the potteries with even scar lines, as if surgical interference, through amputation of the diseased areas, had attempted to arrest the advance of the disease. Such water jars are fairly common, but in no other country has pathology received such plastic representations as in ancient Peru. (Original examples of the pottery are in the American Museum of Natural History.)

The early Peruvian, like many another primitive race, quite early became adepts at pottery-making. Unlike other races, however, they represented on the pottery objects the manifestations of nature around them. This was true of the several tribes composing the former Peruvian civilization. Among many other objects, that of disease came in for its share of representation, so we have preserved to us representations of men afflicted with *uta*, *verruga Peruviana*, amputated limbs, *gondou*, and surgical incisions for removal of the burrowing jigger from the soles of the feet. From these vessels in pottery we are assured of the age of the diseases there depicted. *Uta*, especially, seems (Fig. 31) to have been prevalent in former times and is common today. It is the Leishmaniosis of parasitologists, and manifests itself in horrid lesions of the face, being especially common around the mouth. Facial features exactly comparable to those depicted on the pre-Columbian pottery may be seen in many of the Indian villages of today. A less commonly represented disease is that of verruga, a skin disease, resulting in nodular eruptions throughout the body. A single example of a water jar, depicting an achondroplastic dwarf, represents this form of pathology in ancient times. Gondou, a disease of the base of the nasal bones, is likewise represented by a single example, but the likeness is so striking there can be no doubt about its interpretation.

PATHOLOGY OF THE PRE-COLUMBIAN INDIANS OF NORTH AMERICA

The primitive predecessors of the white race in the North American Continent were, so far as we can judge, the most healthy and vigorous of all the ancient human races of which we have adequate basis for an opinion. They did not suffer from such modern universal plagues as syphilis, smallpox, *uta*, tuberculosis, scarlet fever, or any other serious afflictions to which the races of Egypt and Peru were subject. Only a single indication of cancer has been found possibly represented in the portions

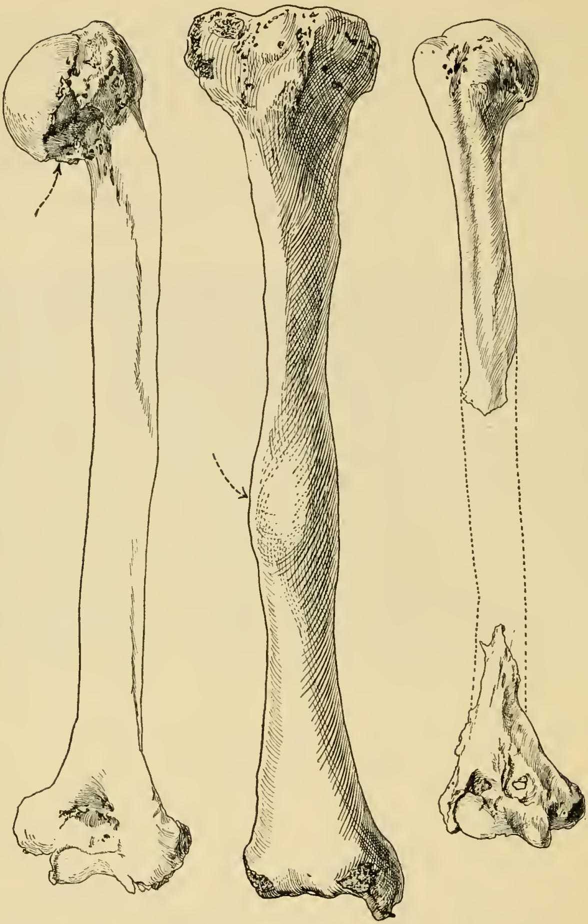

FIG. 32.—Pathology among the pre-Columbian Indians of North America. *Left*, fractured humerus, well healed, of a male pre-Columbian Indian from Huichol, Mexico. The lack of deformation may have been due to surgical interference, since it is well known that the Indians understood the use of bandages. *Center*, well-healed fracture in a right tibia of a male pre-Columbian Indian, anterior view, May's Lick, Kentucky. *Right*, right humerus of a pre-Columbian female Indian, showing a condition resembling sarcoma. The middle of the shaft has disappeared with the remaining ends tapering toward the lesion. Pueblo, San Cristobal, New Mexico. (Originals in American Museum of Natural History.)

of a humerus preserved from an ancient grave in Utah. Nor were caries or other dental disturbances prevalent. Part of our lack of knowledge may be due to the supposed custom of disposing of diseased or maimed individuals. The North American Indians did not look upon the care of the helpless as a duty, as did the ancient Egyptians. But taking into consideration all known factors the ancient red men were a very healthy race. The introduction of disease came with the coming of white men and here we see the disastrous effect of disease in bringing about the extinction of a primitive race.

Few studies on ancient pathology have been made, and such as are known are of doubtful chronology since there is the greatest difficulty in discriminating between skeletons of true pre-Columbian age and those of a later period. The Indians used the same burials for centuries and often interred a recent body in the grave of a more ancient burial.

The pre-Columbian Indians suffered from a variety of injuries and disease, many of which resulted in surgical conditions. Whitney has described skull fractures, arrow-point wounds, fracture of the clavicle, arm, femur, as well as luxation of the hip, congenital and otherwise. Among the constitutional afflictions he mentions a variety of exostoses, periostitis, arthritides, caries, and doubtful evidence of syphilis.

It is curious to note that there are little clay images found in the graves of children in Tennessee, Arkansas, and Missouri, which are faithful representations of persons afflicted with Pott's disease (Fig. 34, p. 139). Many of the water bottles from the stone graves of Tennessee and from the mounds of Missouri represent women with hunchbacks. Tuberculosis of the spine is seldom indicated (Fig. 34, p. 139) in skeletal remains, and it is possible that the clay images do not indicate any great prevalence of Pott's disease in these localities but represent other spinal deformities.

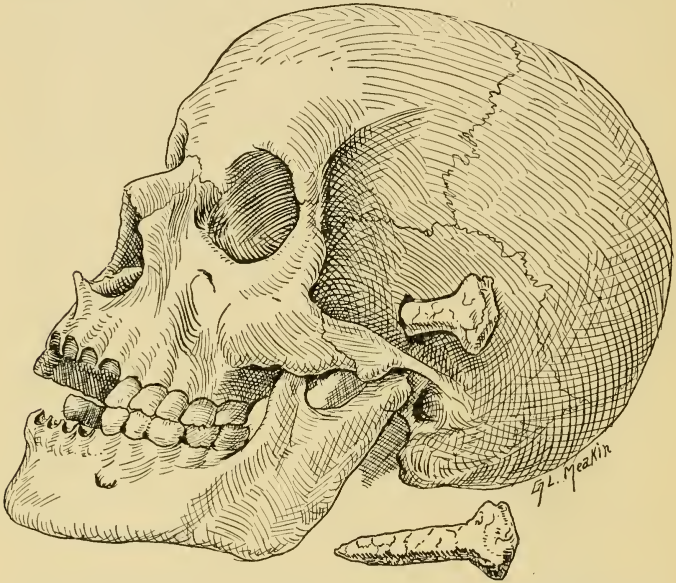

Fig. 33.—Arrow-point injuries suggest an interesting phase of paleopathology, one which has been very little studied. Often some insight into the life of ancient man can be had from the injuries he received in war or in the chase. The skull is that of a North American Indian, and since the arrow point was found imbedded in the bone it undoubtedly caused the death of the individual (after Wilson).

The mound-builders of ancient times, in the Mississippi Valley, show in the skeletal remains many gross pathological changes. Evidences of injury with the formation of callus, complete ankylosis of humerus and ulna, periostitis, osteoperiostitis, osteitis deformans, slight arthritides, fractured ribs, and spondylitis deformans all indicate the degree of pathology among the ancient tribes. A serious illness is usually required to effect changes in the bones. There is no definite evidence of rickets. Trephining was unknown north of Mexico.

FIG. 34.—Primitive pottery from an ancient grave in Tennessee, suggesting in the marked scoliosis the presence of Pott's disease in the tribe by which the pottery was used. Note the crudity of design compared to the finished products shown in Fig. 28.

The history of the Indians is intimately associated with that of the bison, which was the chief food supply for many nations. It is fitting that we should close this account of ancient pathology with a note on the pathology of bison remains. The lesions known are all due to injuries: gunshot wounds, spear-point injuries, fractures, contusions, and other traumatisms. Osteomyelitis (Fig. 36) was a very frequent result of injuries, since in the nature of the case an injured bison was not left in peace to recuperate. He was annoyed by coyotes,

FIG. 35.—Rheumatism seems to have been very common among the pre-Columbian tribes of North American Indians. The present scapulae indicate a mild form of pathology compared to what the ancient Egyptians suffered, but still severe enough. The articular surfaces are eburnated, deformed, and lipped by osteophytes of new bone due to the irritating effects of infective bacteria. The lesions undoubtedly caused considerable limitation of movement of the member as well as intense pain. (Specimens in the American Museum of Natural History.)

attacked by wolves, or pursued by the red men. Enforced action following an injury induced infections and the consequent irritation resulted in the formation of callus. An interesting example of a false joint following a fracture is known. The pseudarthrosis was accompanied by huge exostoses. No constitutional diseases of the bison are known, nor should we expect to meet any.

FIG. 36.—The most recent phase of paleopathology is certainly that of the study of the diseases of the American bison, so recently become extinct as to be within the memory of many now living. The injuries were received after the coming of white men, in the specimens studied, since one osteomyelitis shows in its large necrotic sinus a leaden bullet. The present specimen was collected in western Kansas in the days when the bison still roamed the plains in great numbers

Animals afflicted with disease or injury, whether young or old, very soon succumbed to the hostile acts of predatory animals or man. Few survived sufficiently long for osseous changes to develop, for life with the ancient bison was a fierce struggle for existence. They, like the primitive human races, became extinct following the introduction of the white race.

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Celacea

great horned
Cat 5 - bird
blue - jay